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Xi et al.

(10) **Patent No.: US 9,143,213 B2**
(45) **Date of Patent: *Sep. 22, 2015**

(54) **METHOD AND APPARATUS FOR MULTI-ANTENNA TRANSMISSION IN UPLINK**

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(73) Assignee: **InterDigital Patent Holdings, Inc.**, Wilmington, DE (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/172,615**

(22) Filed: **Feb. 4, 2014**

(65) **Prior Publication Data**

US 2014/0153668 A1 Jun. 5, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/718,177, filed on Dec. 18, 2012, now Pat. No. 8,665,990, which is a continuation of application No. 12/894,556, filed on Sep. 30, 2010, now Pat. No. 8,355,424.

(Continued)

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H04B 7/06 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***H04B 7/06*** (2013.01); ***H04B 7/0404*** (2013.01); ***H04B 7/0456*** (2013.01);

(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

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Primary Examiner — Adolf Dsouza
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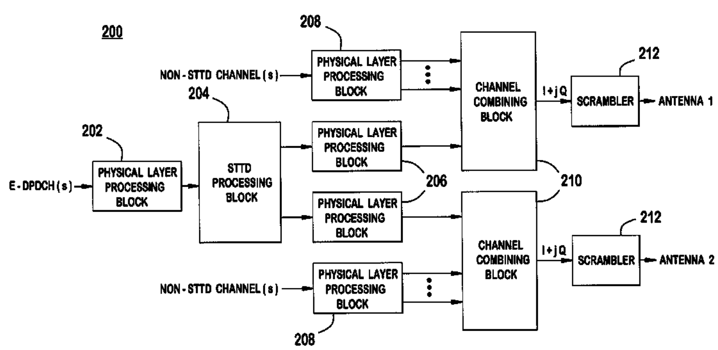
(57) **ABSTRACT**

Method and apparatus for uplink transmission using multiple antennas are disclosed. A wireless transmit/receive unit (WTRU) performs space time transmit diversity (STTD) encoding on an input stream of a physical channel configured for STTD. Each physical channel may be mapped to either an in-phase (I) branch or a quadrature-phase (Q) branch. The WTRU may perform the STTD encoding either in a binary domain or in a complex domain. Additionally, the WTRU may perform pre-coding on at least one physical channel including the E-DPDCH with the pre-coding weights, and transmitting the pre-coded output streams via a plurality of antennas. The pre-coding may be performed either after or before spreading operation.

6 Claims, 39 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 61/247,123, filed on Sep. 30, 2009, provisional application No. 61/248,313, filed on Oct. 2, 2009, provisional application No. 61/356,320, filed on Jun. 18, 2010.

(51) **Int. Cl.**

H04L 1/06	(2006.01)
H04L 27/36	(2006.01)
H04B 7/04	(2006.01)

(52) **U.S. Cl.**
CPC ***H04B 7/0617*** (2013.01); ***H04B 7/0623*** (2013.01); ***H04B 7/0669*** (2013.01); ***H04L 1/0625*** (2013.01); ***H04L 1/0668*** (2013.01); ***H04L 27/362*** (2013.01)

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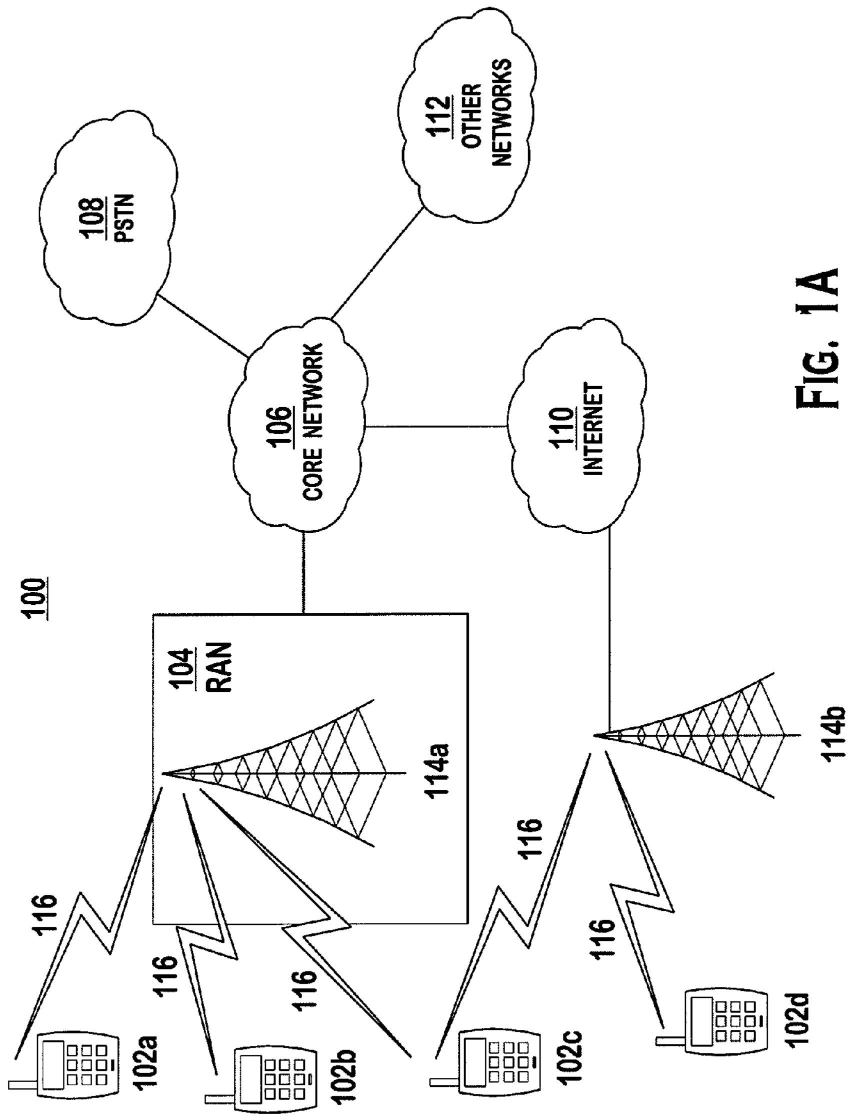

100
104
RAN
106
CORE NETWORK
108
PSTN
110
INTERNET
112
OTHER NETWORKS
114a
114b
116
116
116
116
116
102a
102b
102c
102d

FIG. 1A

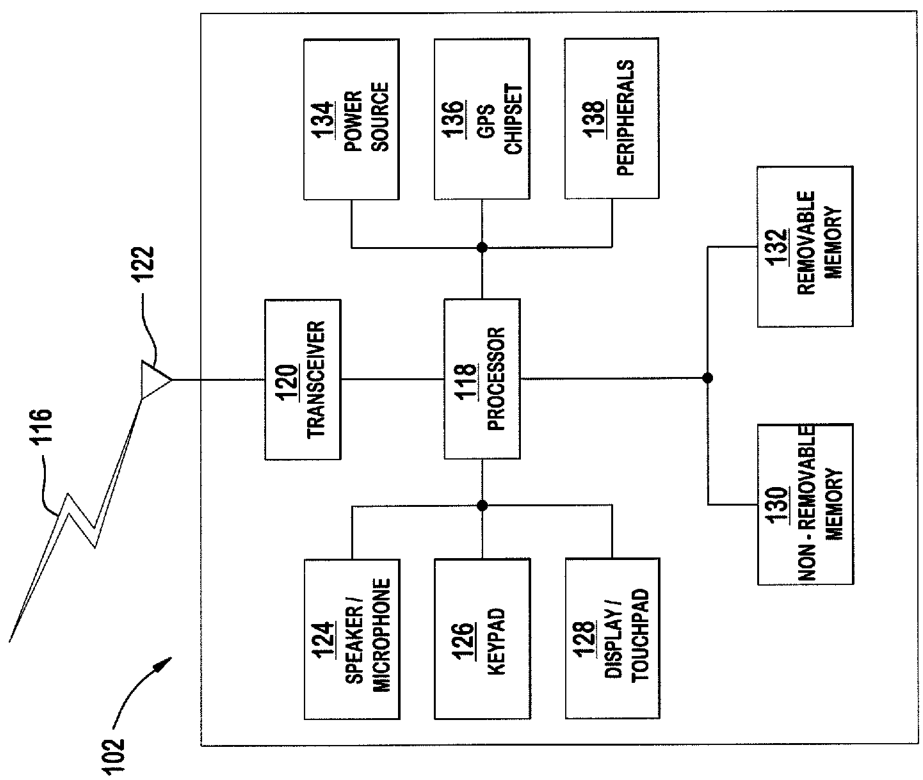

102
116
122
120 TRANSCEIVER
118 PROCESSOR
124 SPEAKER / MICROPHONE
126 KEYPAD
128 DISPLAY / TOUCHPAD
130 NON - REMOVABLE MEMORY
132 REMOVABLE MEMORY
134 POWER SOURCE
136 GPS CHIPSET
138 PERIPHERALS

FIG. 1B

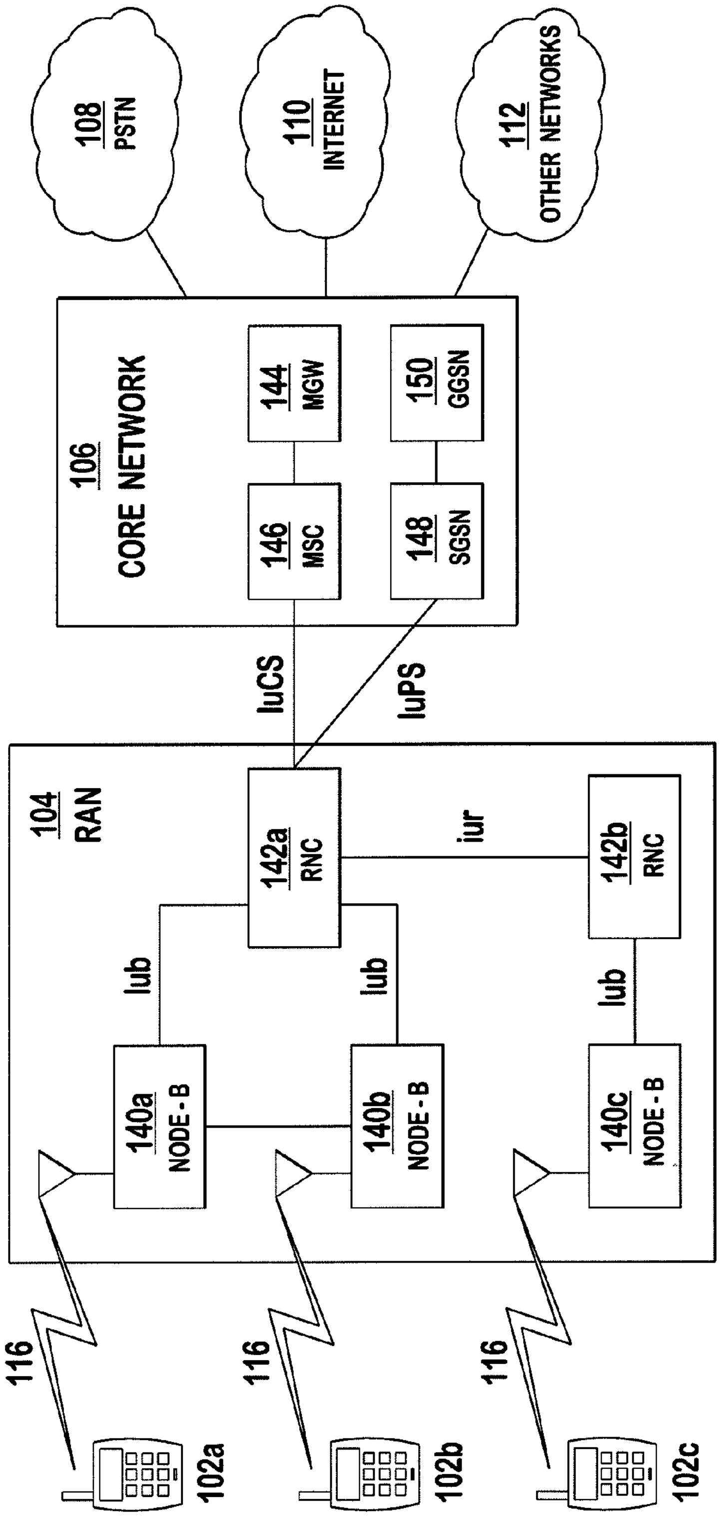
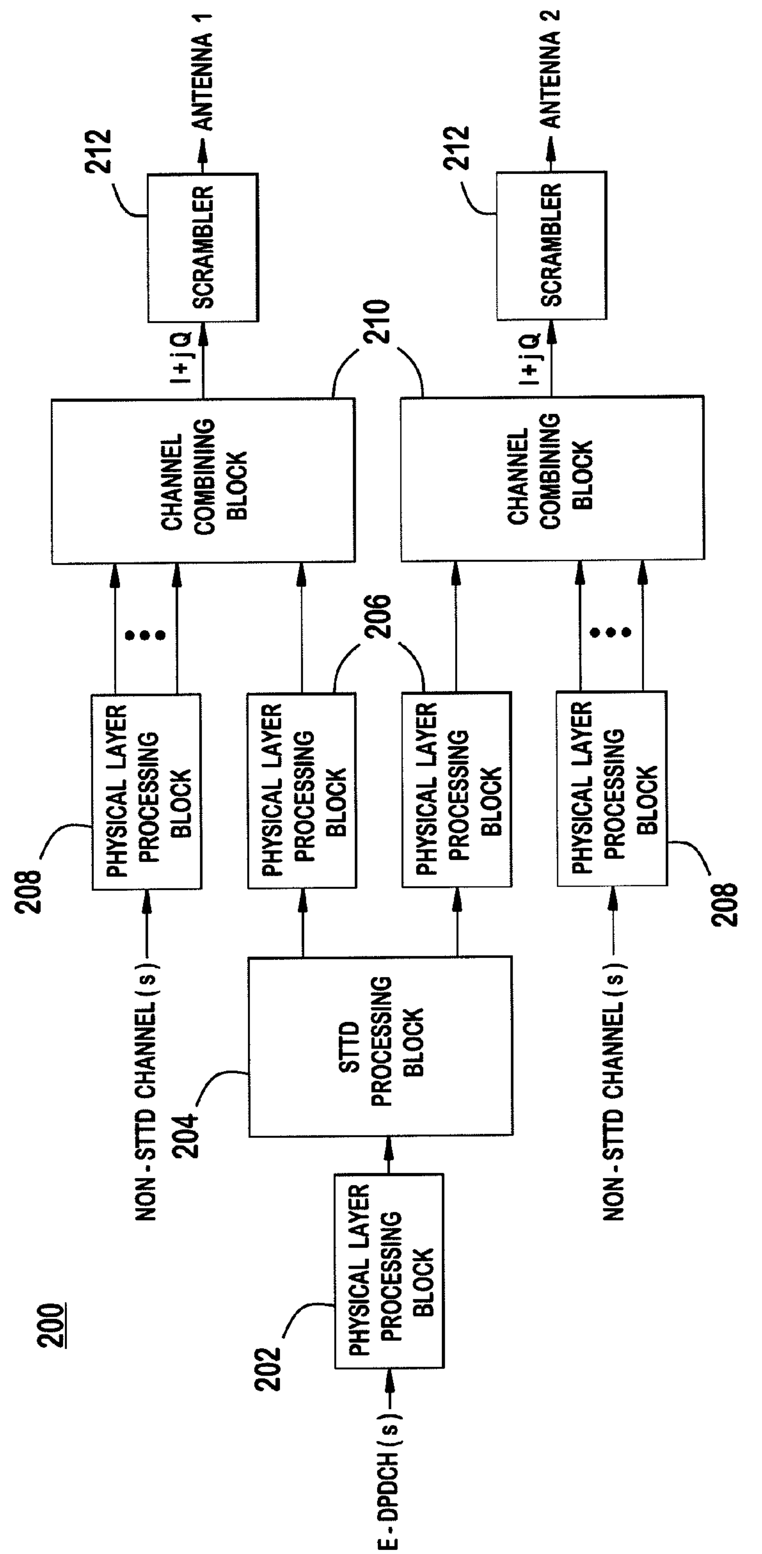
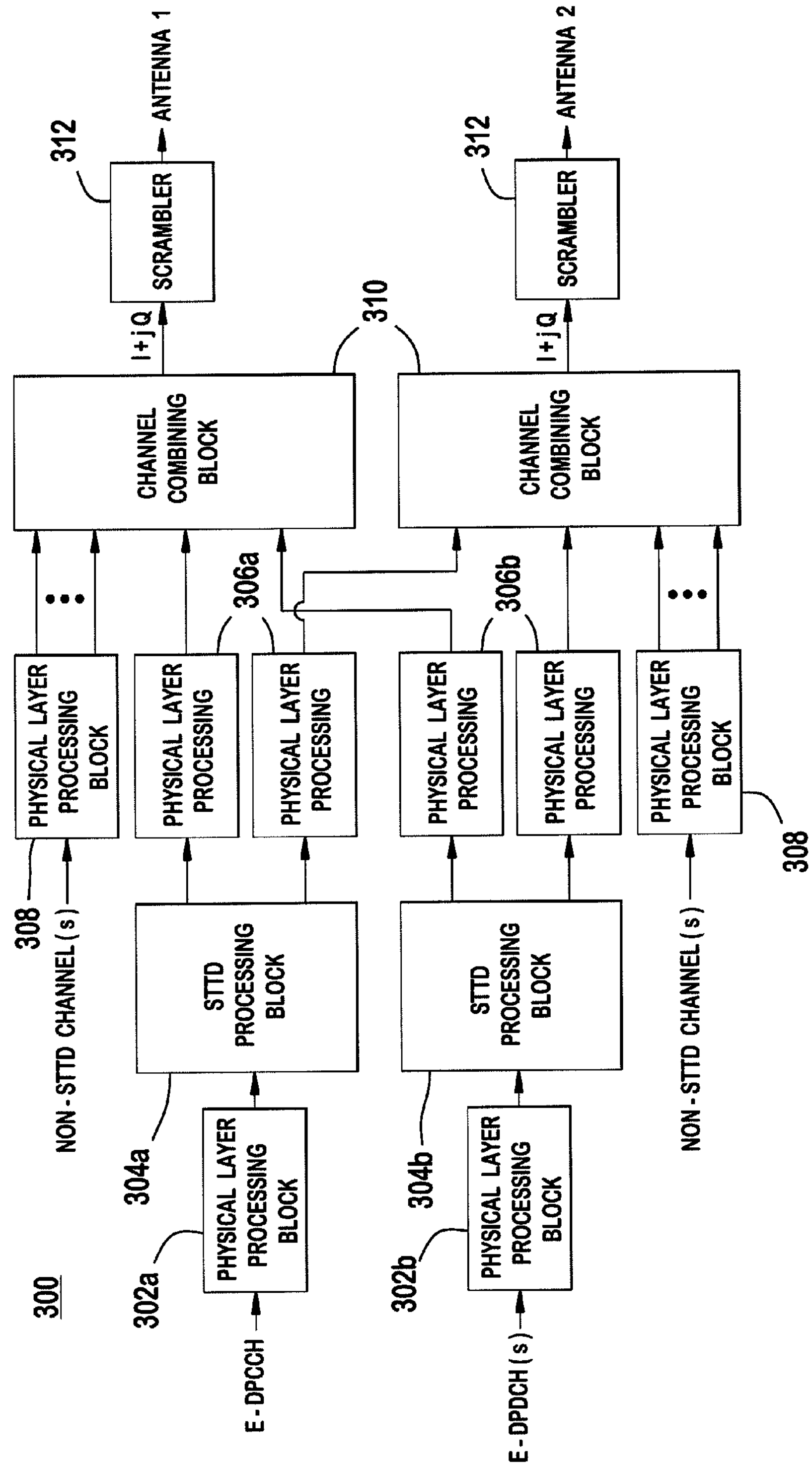

108
PSTN
110
INTERNET
112
OTHER NETWORKS
106
CORE NETWORK
144
MGW
146
MSC
150
GGSN
148
SGSN
IuCS
IuPS
104
RAN
142a
RNC
142b
RNC
iur
Iub
Iub
Iub
140a
NODE - B
140b
NODE - B
140c
NODE - B
116
116
116
102a
102b
102c

FIG. 1C



200
E-DPDCH(s)
202
PHYSICAL LAYER PROCESSING BLOCK
204
STTD PROCESSING BLOCK
206
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
NON-STTD CHANNEL(s)
208
PHYSICAL LAYER PROCESSING BLOCK
NON-STTD CHANNEL(s)
PHYSICAL LAYER PROCESSING BLOCK
208
210
CHANNEL COMBINING BLOCK
CHANNEL COMBINING BLOCK
I+jQ
I+jQ
212
SCRAMBLER
ANTENNA 1
212
SCRAMBLER
ANTENNA 2

FIG. 2



300
E-DPCCH
302a
PHYSICAL LAYER PROCESSING BLOCK
304a
STTD PROCESSING BLOCK
E-DPDCH(s)
302b
PHYSICAL LAYER PROCESSING BLOCK
304b
STTD PROCESSING BLOCK
NON-STTD CHANNEL(s)
308
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING
PHYSICAL LAYER PROCESSING
306a
PHYSICAL LAYER PROCESSING
PHYSICAL LAYER PROCESSING
306b
PHYSICAL LAYER PROCESSING BLOCK
NON-STTD CHANNEL(s)
308
CHANNEL COMBINING BLOCK
CHANNEL COMBINING BLOCK
310
I+jQ
I+jQ
SCRAMBLER
SCRAMBLER
312
312
ANTENNA 1
ANTENNA 2

FIG. 3

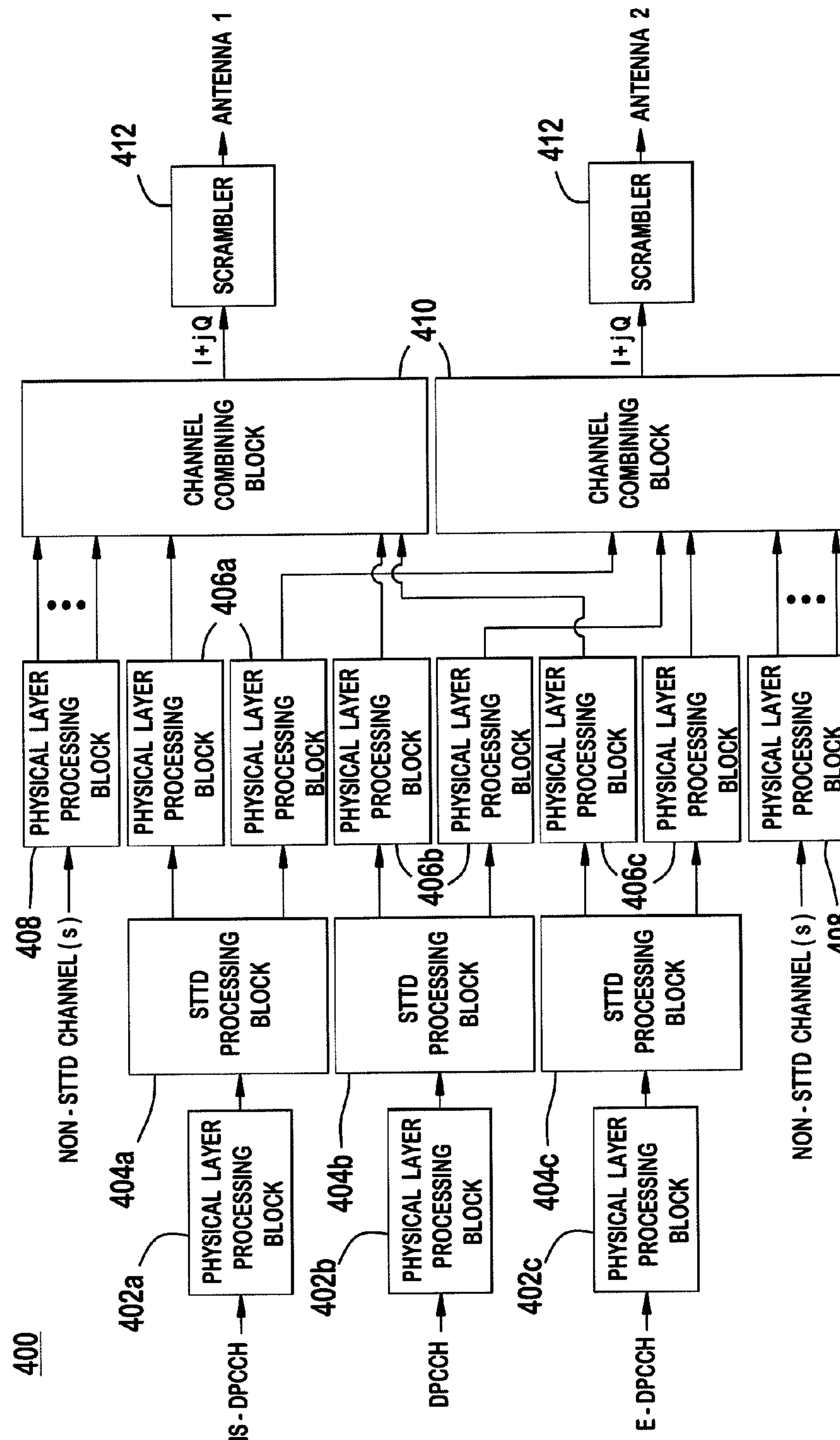

400
HS-DPCCH
DPCCH
E-DPCCH
402a
402b
402c
PHYSICAL LAYER PROCESSING BLOCK
404a
404b
404c
STTD PROCESSING BLOCK
406a
406b
406c
408
NON-STTD CHANNEL(s)
410
CHANNEL COMBINING BLOCK
I+jQ
412
SCRAMBLER
ANTENNA 1
ANTENNA 2

FIG. 4

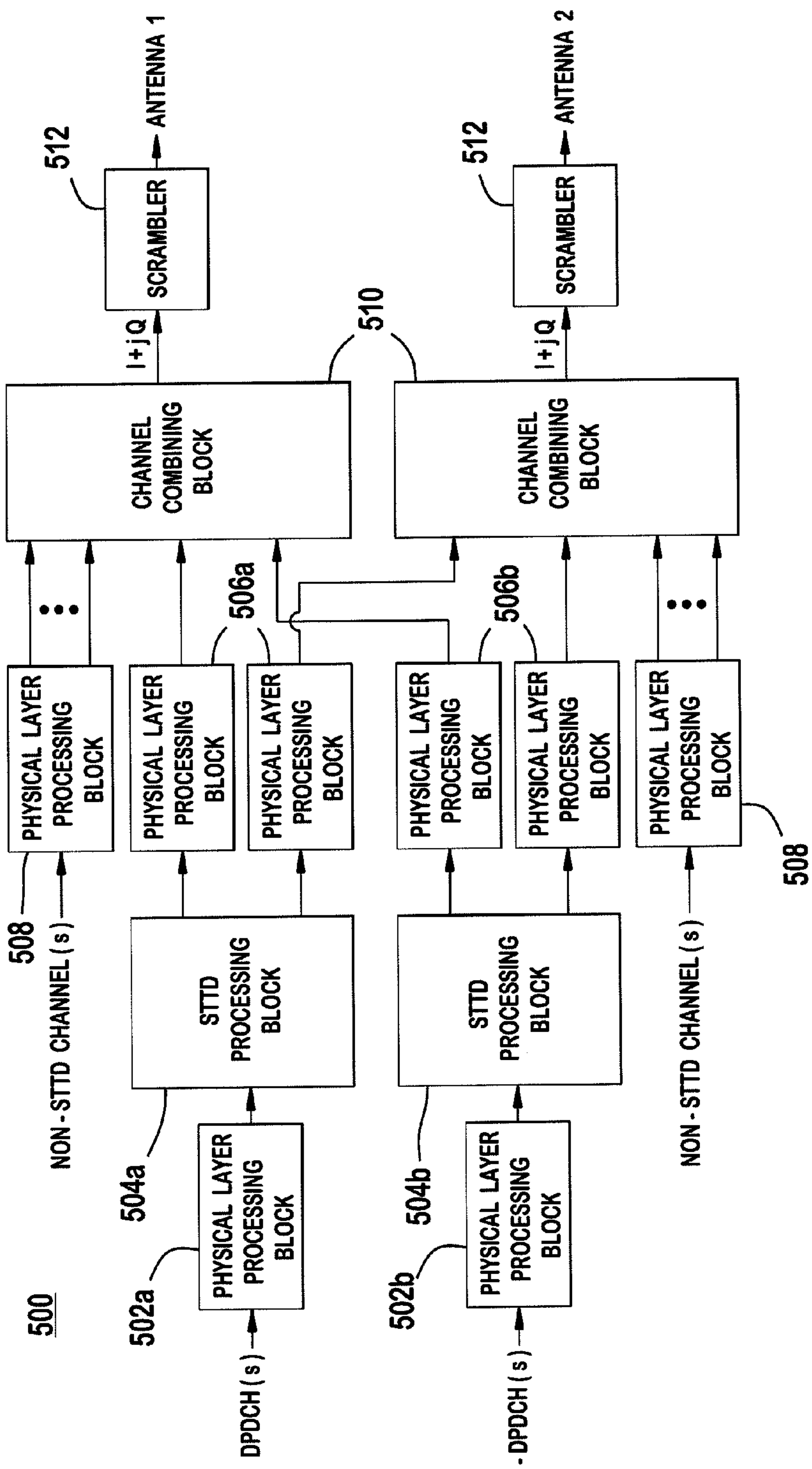

500
DPDCH (s)
502a
PHYSICAL LAYER PROCESSING BLOCK
504a
STTD PROCESSING BLOCK
E - DPDCH (s)
502b
PHYSICAL LAYER PROCESSING BLOCK
504b
STTD PROCESSING BLOCK
NON - STTD CHANNEL (s)
508
PHYSICAL LAYER PROCESSING BLOCK
506a
506b
CHANNEL COMBINING BLOCK
510
I + j Q
SCRAMBLER
512
ANTENNA 1
ANTENNA 2

FIG. 5

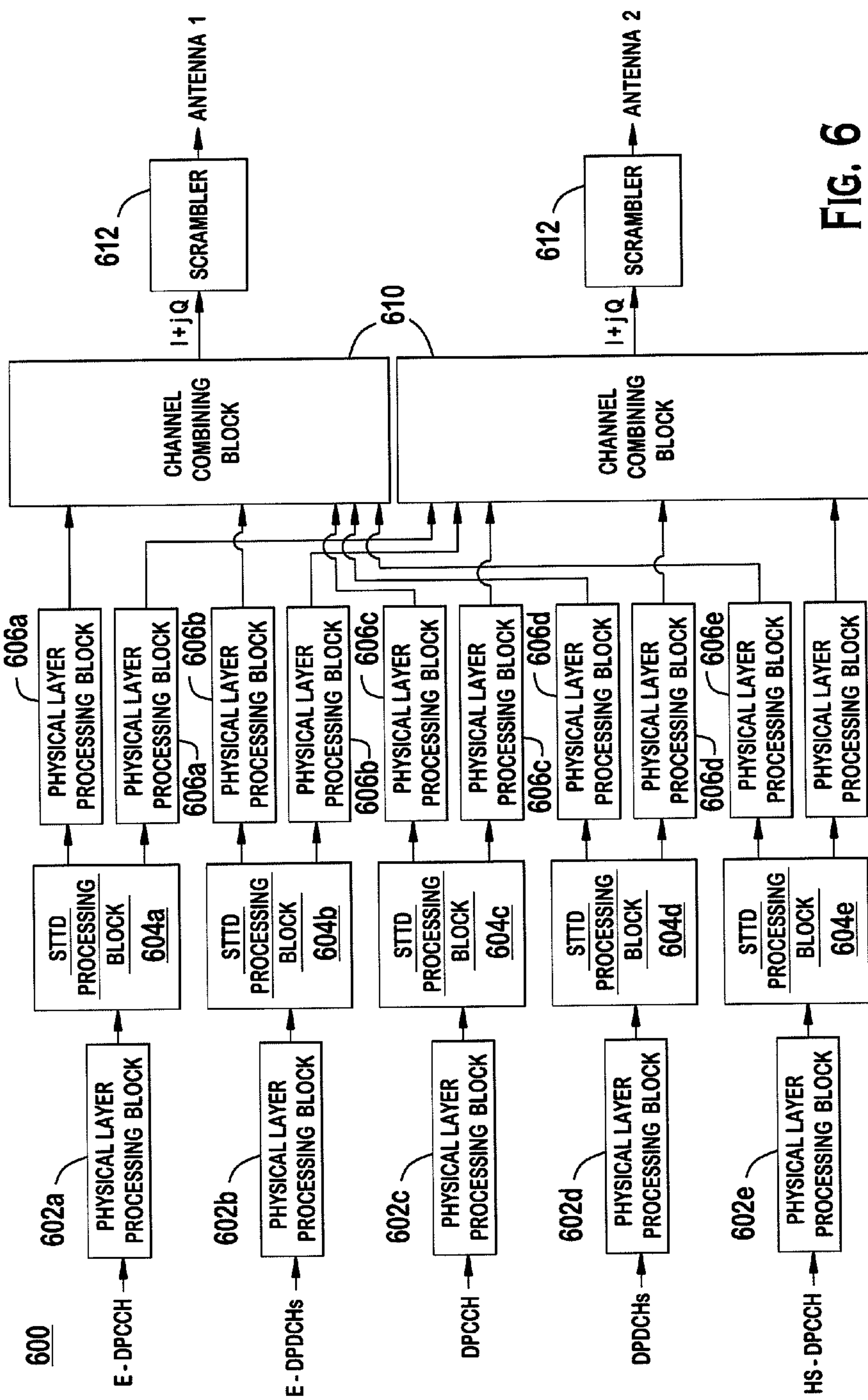

600
E-DPCCH
E-DPDCHs
DPCCH
DPDCHs
HS-DPCCH
602a
602b
602c
602d
602e
PHYSICAL LAYER PROCESSING BLOCK
STTD PROCESSING BLOCK 604a
STTD PROCESSING BLOCK 604b
STTD PROCESSING BLOCK 604c
STTD PROCESSING BLOCK 604d
STTD PROCESSING BLOCK 604e
606a
606b
606c
606d
606e
CHANNEL COMBINING BLOCK
610
I+jQ
612
SCRAMBLER
ANTENNA 1
ANTENNA 2

FIG. 6

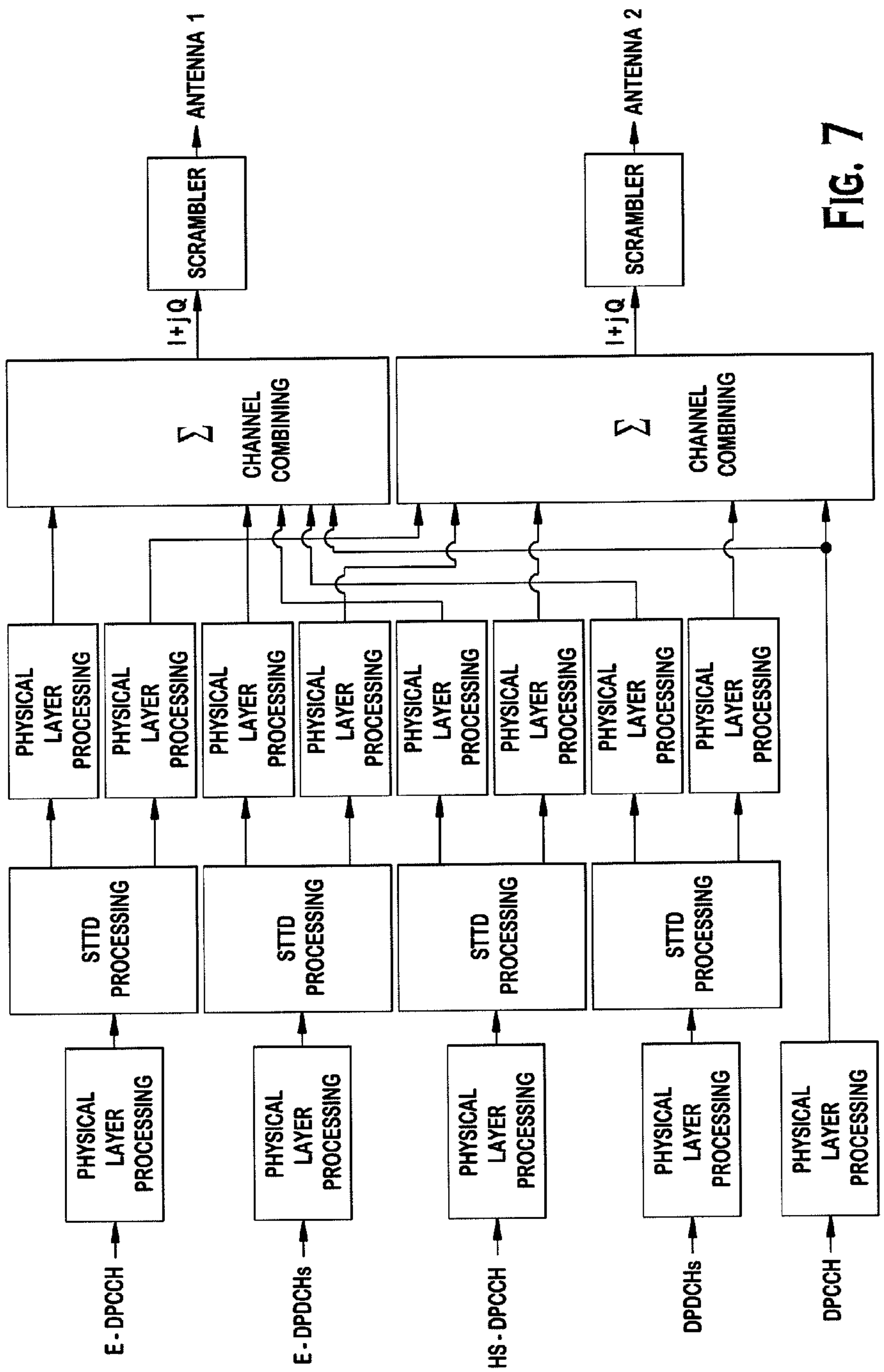

E-DPCCH
E-DPDCHs
HS-DPCCH
DPDCHs
DPCCH
PHYSICAL LAYER PROCESSING
STTD PROCESSING
Σ CHANNEL COMBINING
I+jQ
SCRAMBLER
ANTENNA 1
ANTENNA 2

FIG. 7

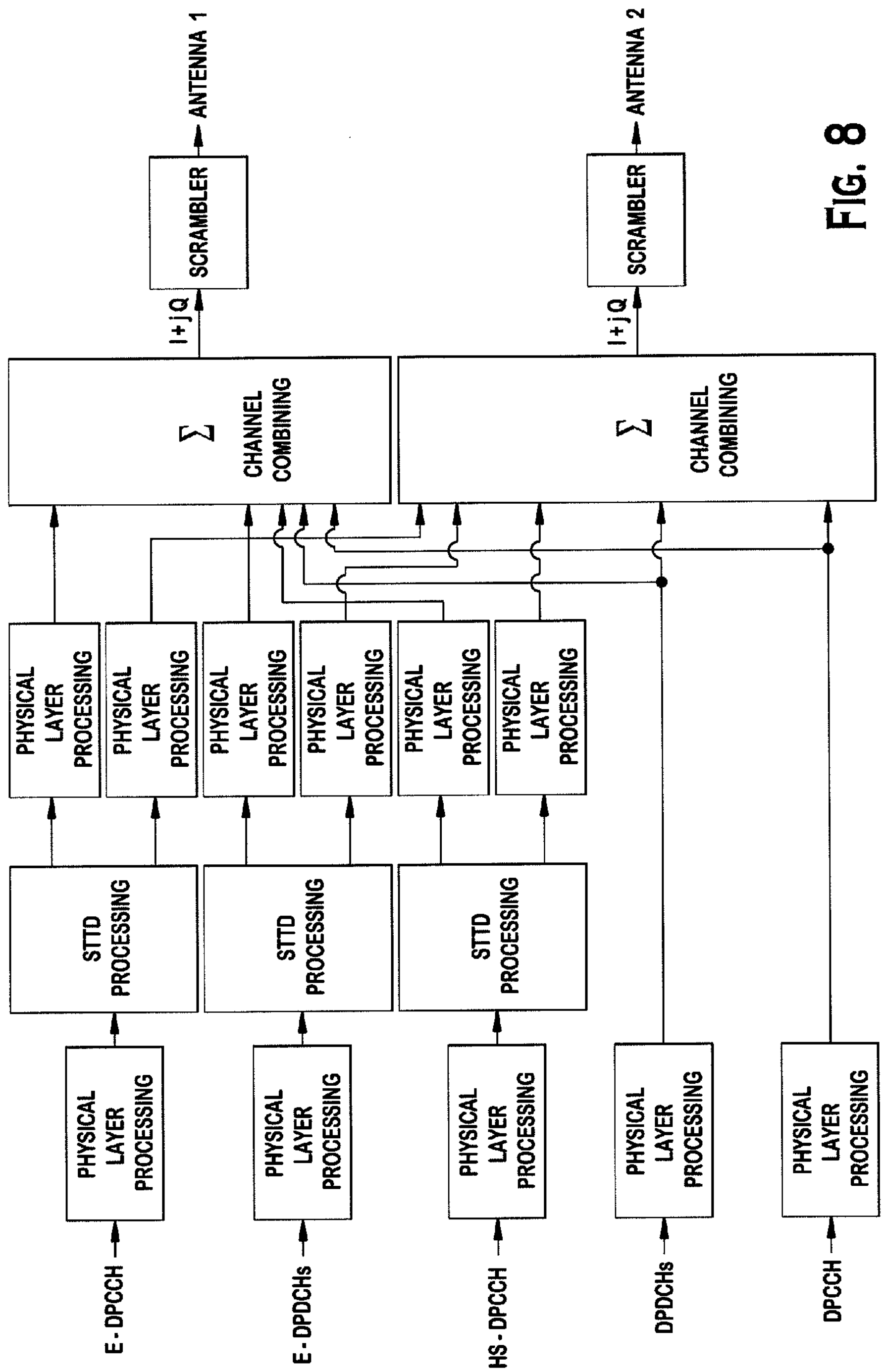

E-DPCCH
E-DPDCHs
HS-DPCCH
DPDCHs
DPCCH
PHYSICAL LAYER PROCESSING
STTD PROCESSING
Σ
CHANNEL COMBINING
I+jQ
SCRAMBLER
ANTENNA 1
ANTENNA 2

FIG. 8

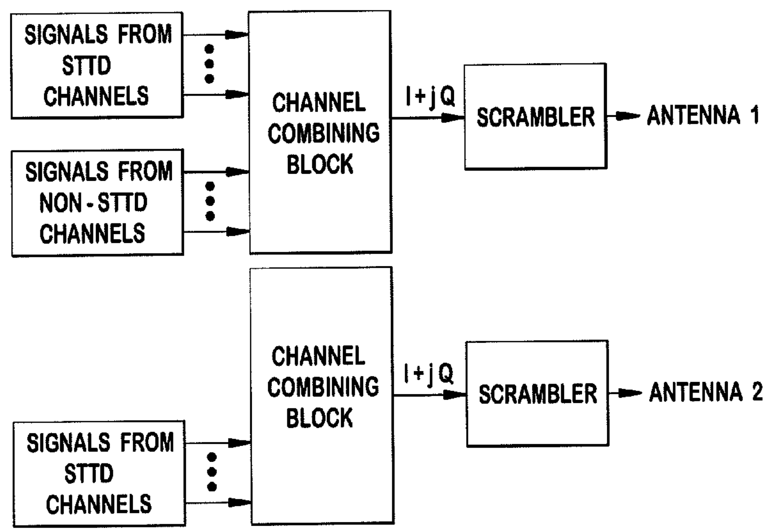

SIGNALS FROM STTD CHANNELS
SIGNALS FROM NON-STTD CHANNELS
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 1
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 2
SIGNALS FROM STTD CHANNELS

FIG. 9(A)

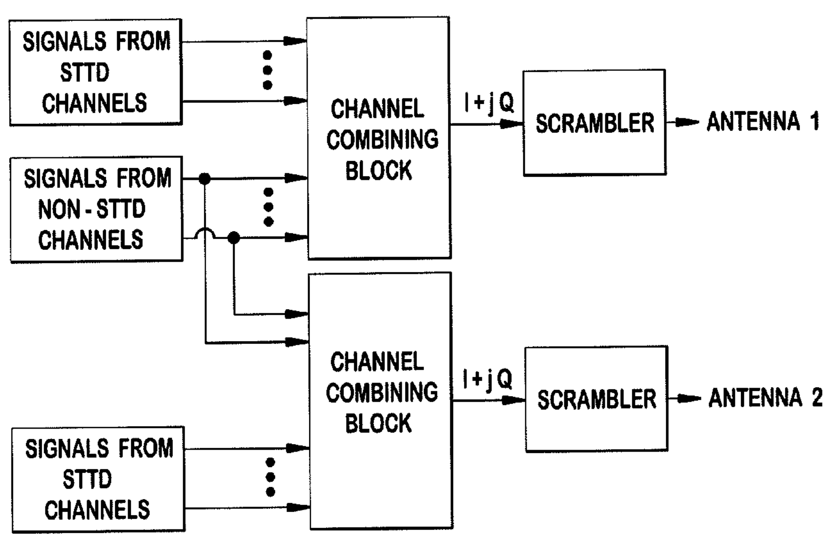

SIGNALS FROM STTD CHANNELS
SIGNALS FROM NON-STTD CHANNELS
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 1
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 2
SIGNALS FROM STTD CHANNELS

FIG. 9(B)

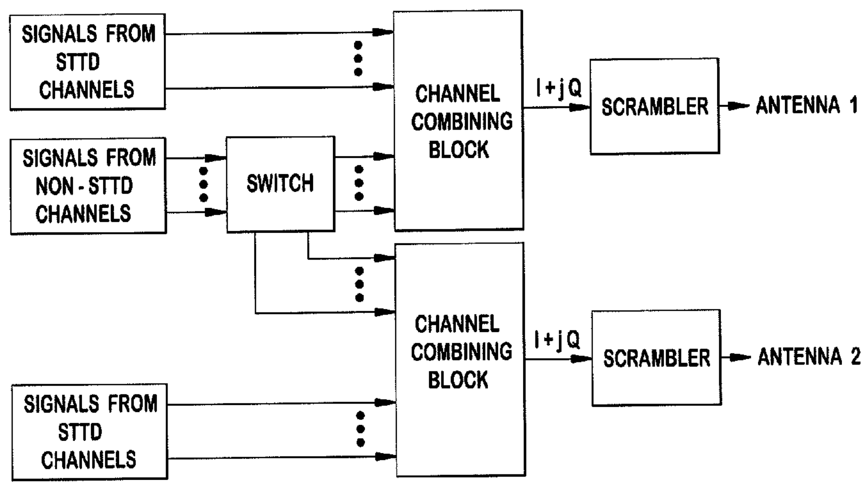

SIGNALS FROM STTD CHANNELS
SIGNALS FROM NON-STTD CHANNELS
SWITCH
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 1
SIGNALS FROM STTD CHANNELS
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 2

FIG. 9(C)

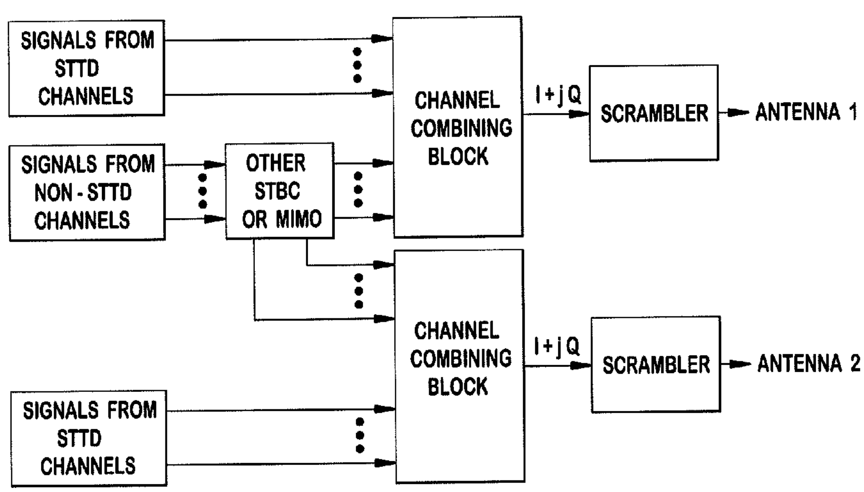

SIGNALS FROM STTD CHANNELS
SIGNALS FROM NON-STTD CHANNELS
OTHER STBC OR MIMO
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 1
SIGNALS FROM STTD CHANNELS
CHANNEL COMBINING BLOCK
I+jQ
SCRAMBLER
ANTENNA 2

FIG. 9(D)

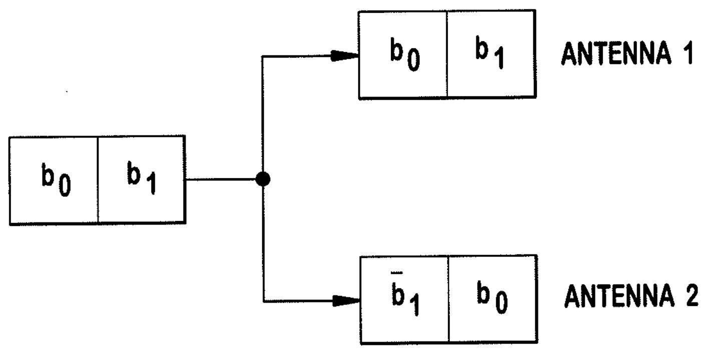


FIG. 10(A)

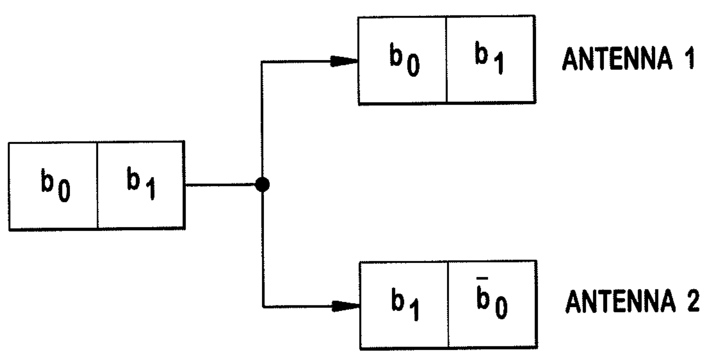


FIG. 10(B)

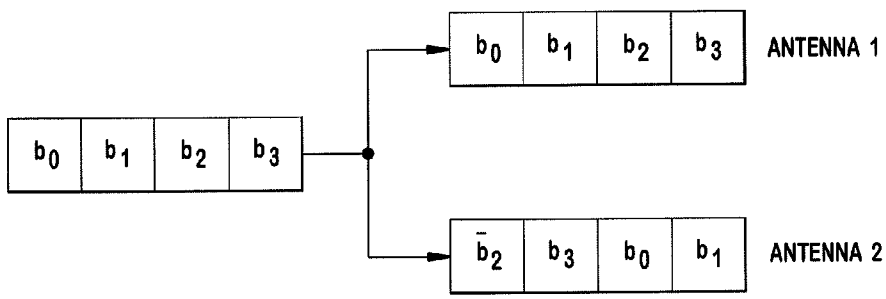


FIG. 11(A)

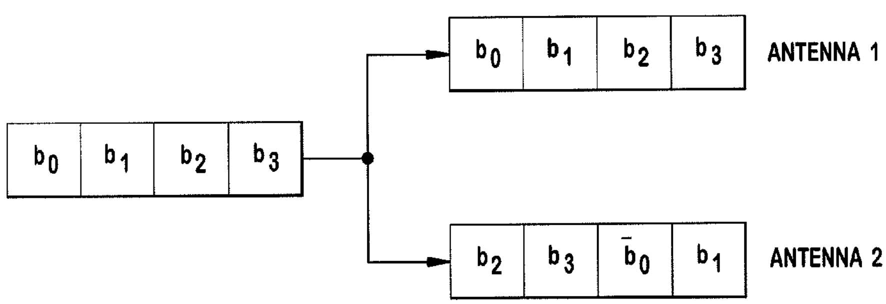


FIG. 11(B)

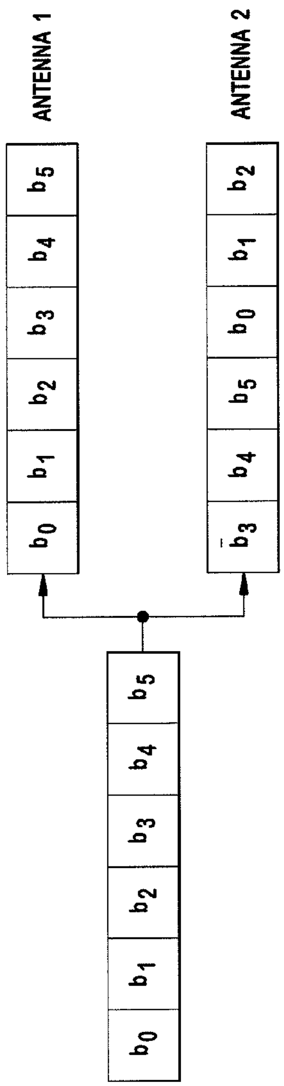


FIG. 12(A)

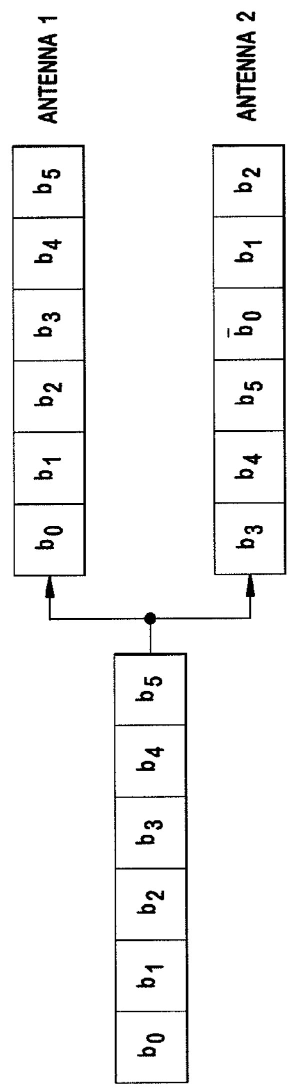


FIG. 12(B)

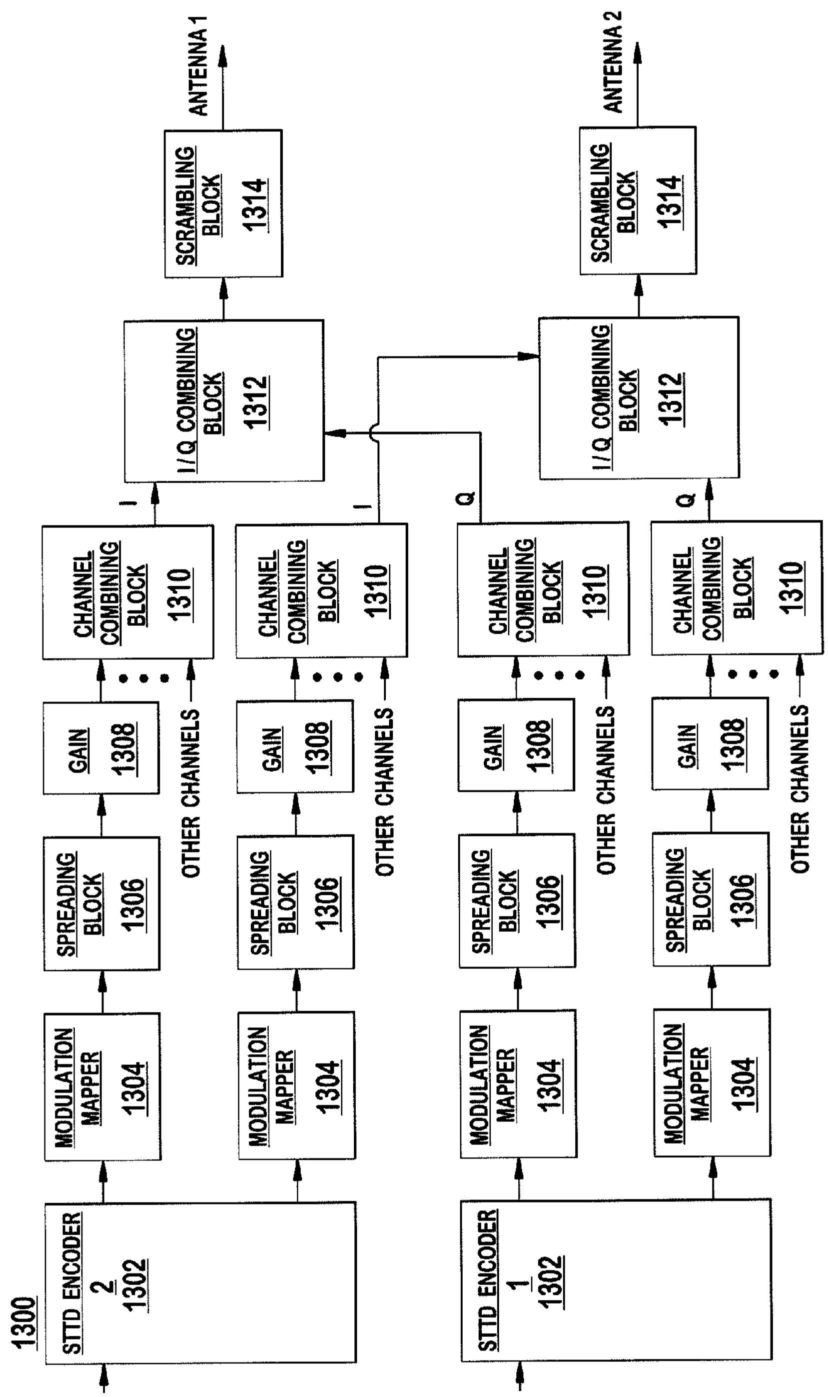
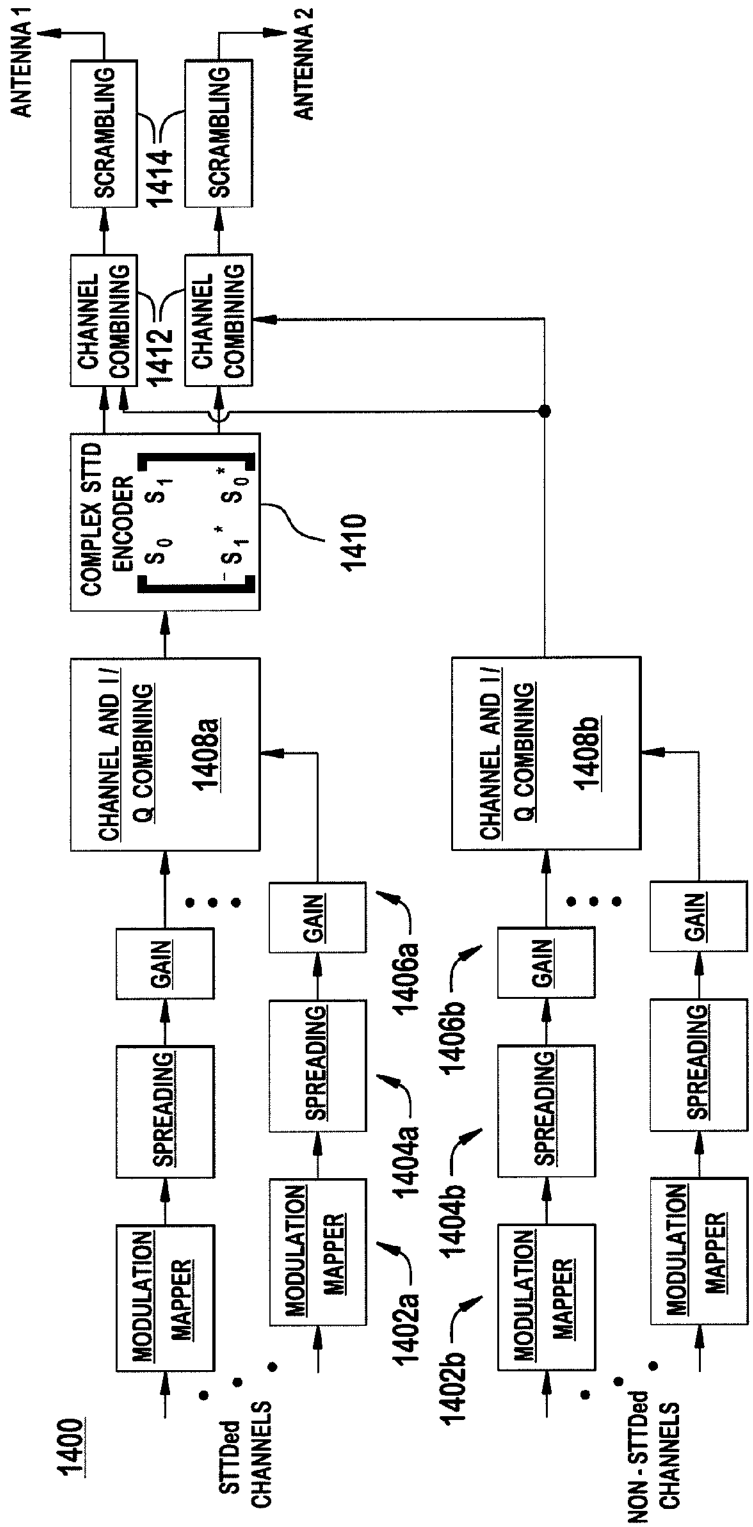

1300
STTD ENCODER 2 1302
STTD ENCODER 1 1302
MODULATION MAPPER 1304
SPREADING BLOCK 1306
GAIN 1308
OTHER CHANNELS
CHANNEL COMBINING BLOCK 1310
I
Q
I / Q COMBINING BLOCK 1312
SCRAMBLING BLOCK 1314
ANTENNA 1
ANTENNA 2

FIG. 13



1400
STTDed CHANNELS
NON - STTDed CHANNELS
MODULATION MAPPER
SPREADING
GAIN
1402a
1404a
1406a
1402b
1404b
1406b
CHANNEL AND I/Q COMBINING
1408a
1408b
COMPLEX STTD ENCODER
S_0 S_1
$-S_1^*$ S_0^*
1410
CHANNEL COMBINING
1412
SCRAMBLING
1414
ANTENNA 1
ANTENNA 2

FIG. 14

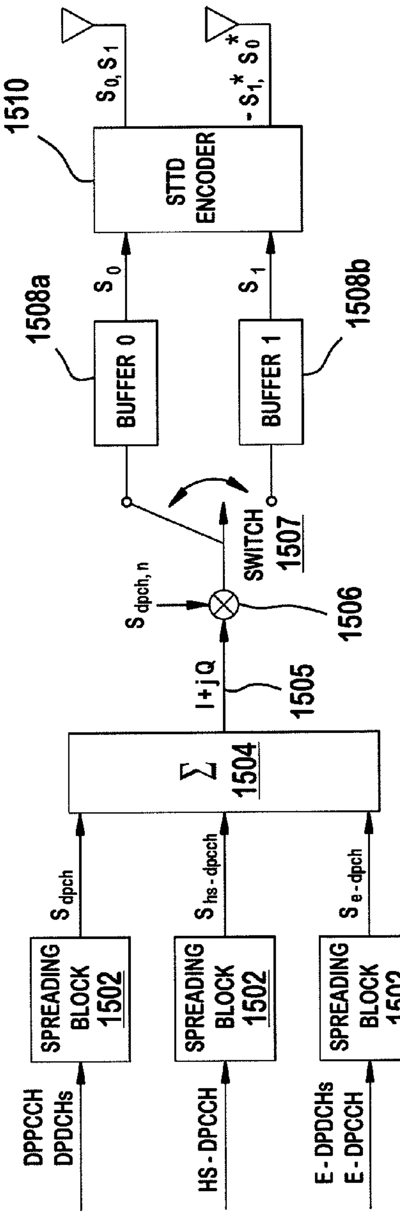

DPPCCH
DPDCHs
HS-DPCCH
E-DPDCHs
E-DPCCH
SPREADING BLOCK 1502
SPREADING BLOCK 1502
SPREADING BLOCK 1502
S dpch
S hs-dpcch
S e-dpch
Σ 1504
I+jQ
1505
S dpch, n
1506
SWITCH 1507
BUFFER 0
BUFFER 1
1508a
1508b
S 0
S 1
STTD ENCODER
1510
S0, S1
-S1*, S0*

FIG. 15

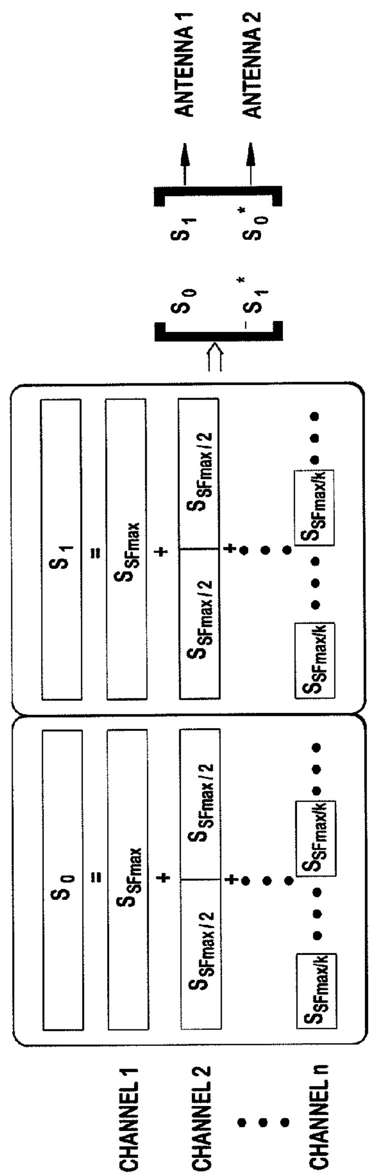
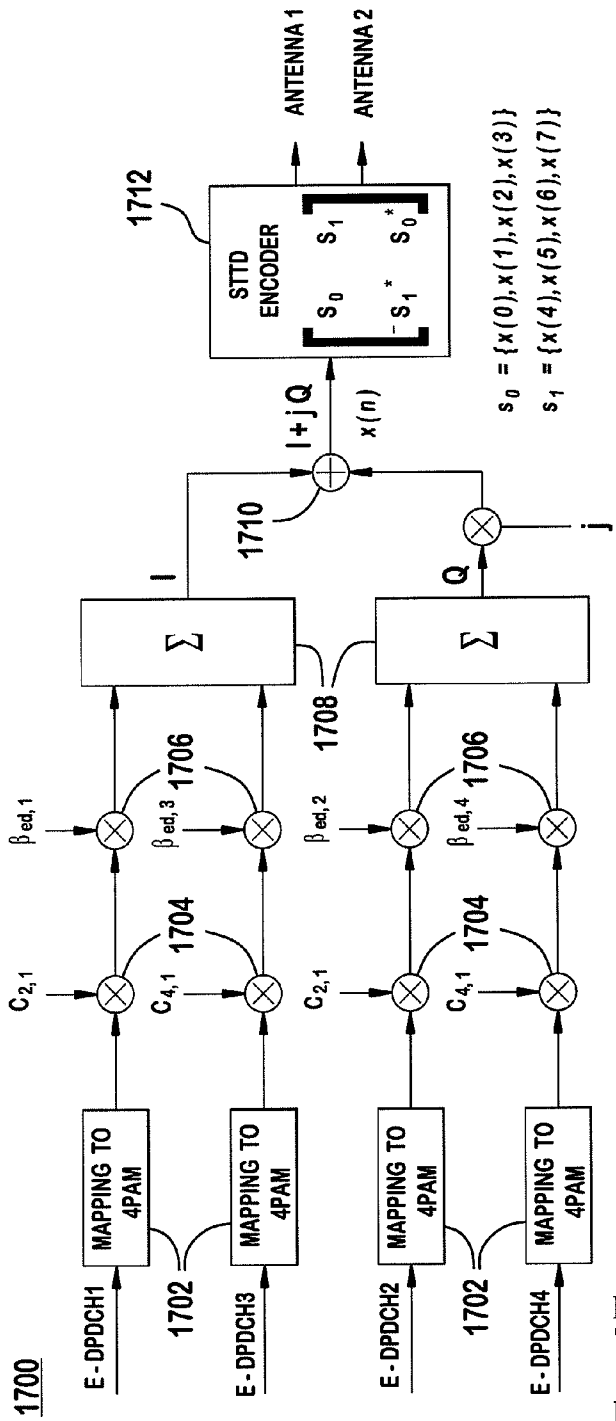
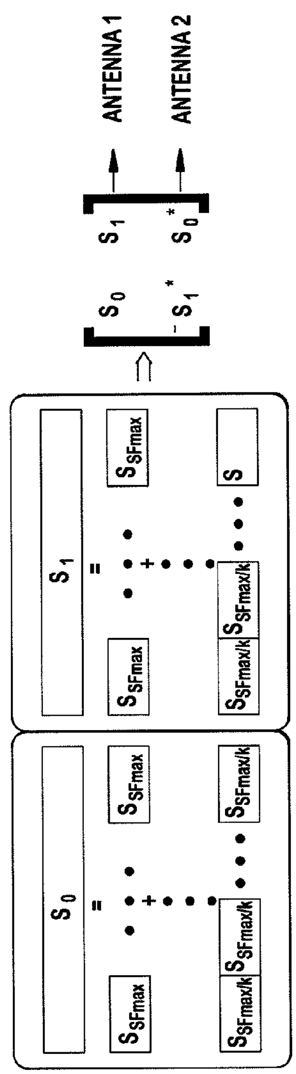

CHANNEL 1
CHANNEL 2
CHANNEL n
S 0
=
S SFmax
+
S SFmax/2
S SFmax/2
S SFmax/k
S 1
ANTENNA 1
ANTENNA 2

FIG. 16



1700
E-DPDCH1
E-DPDCH3
E-DPDCH2
E-DPDCH4
MAPPING TO 4PAM
1702
C2,1
C4,1
1704
βed,1
βed,3
βed,2
βed,4
1706
1708
Σ
I
Q
j
1710
I+jQ
x(n)
1712
STTD ENCODER
S0 S1
-S1* S0*
ANTENNA 1
ANTENNA 2
s0 = {x(0),x(1),x(2),x(3)}
s1 = {x(4),x(5),x(6),x(7)}

FIG. 17



S0
S1
SSFmax
SSFmax/k
S0 S1
-S1* S0*
ANTENNA 1
ANTENNA 2

FIG. 18

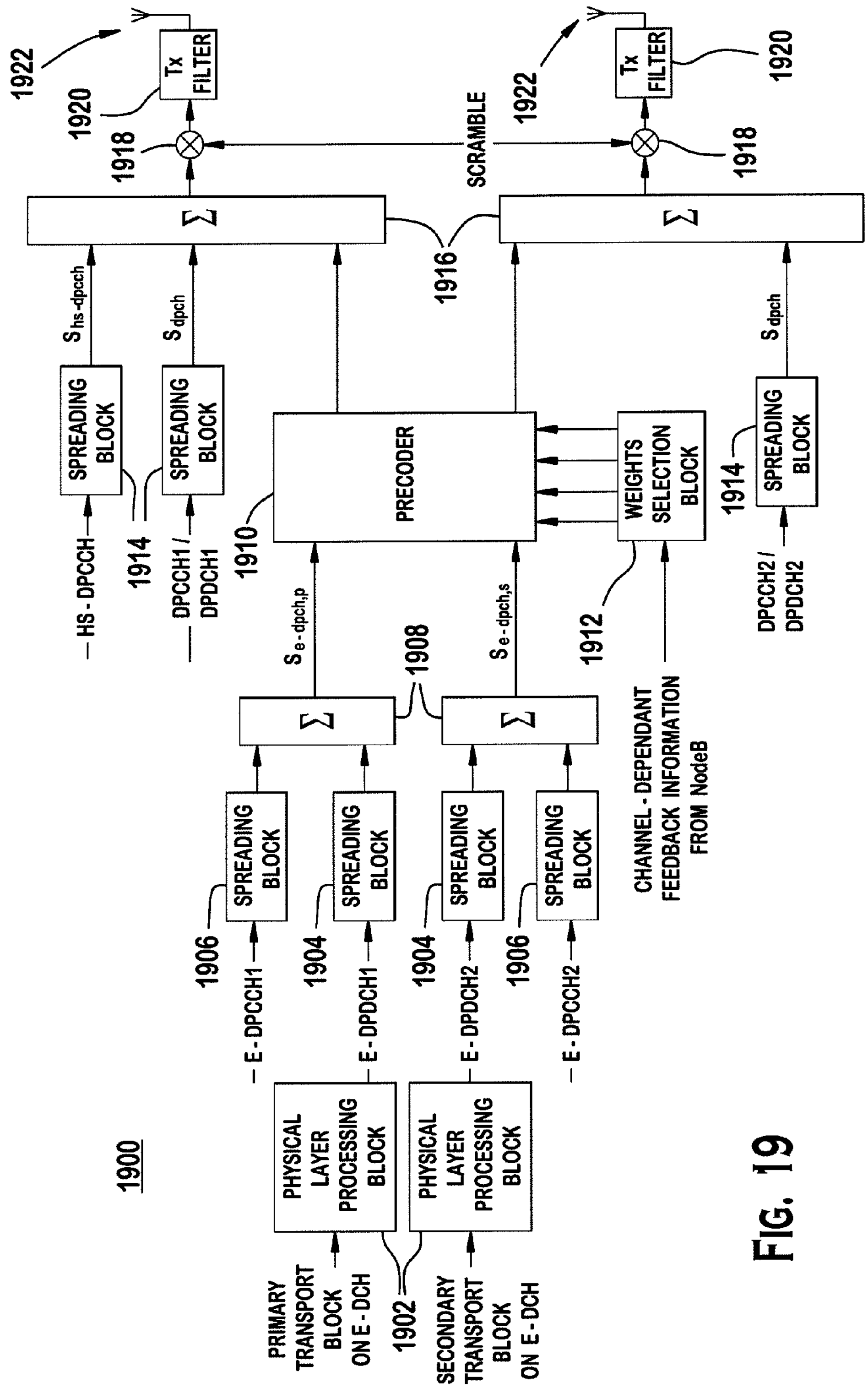

1900
PRIMARY TRANSPORT BLOCK ON E-DCH
SECONDARY TRANSPORT BLOCK ON E-DCH
1902
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
E-DPCCH1
E-DPDCH1
E-DPDCH2
E-DPCCH2
1906
1904
1904
1906
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
Σ
Σ
1908
$S_{e-dpch,p}$
$S_{e-dpch,s}$
CHANNEL-DEPENDANT FEEDBACK INFORMATION FROM NodeB
1912
WEIGHTS SELECTION BLOCK
1910
PRECODER
HS-DPCCH
DPCCH1 / DPDCH1
1914
SPREADING BLOCK
SPREADING BLOCK
$S_{hs-dpcch}$
S_{dpch}
DPCCH2 / DPDCH2
1914
SPREADING BLOCK
S_{dpch}
1916
Σ
Σ
SCRAMBLE
1918
1918
1920
1920
Tx FILTER
Tx FILTER
1922
1922

FIG. 19

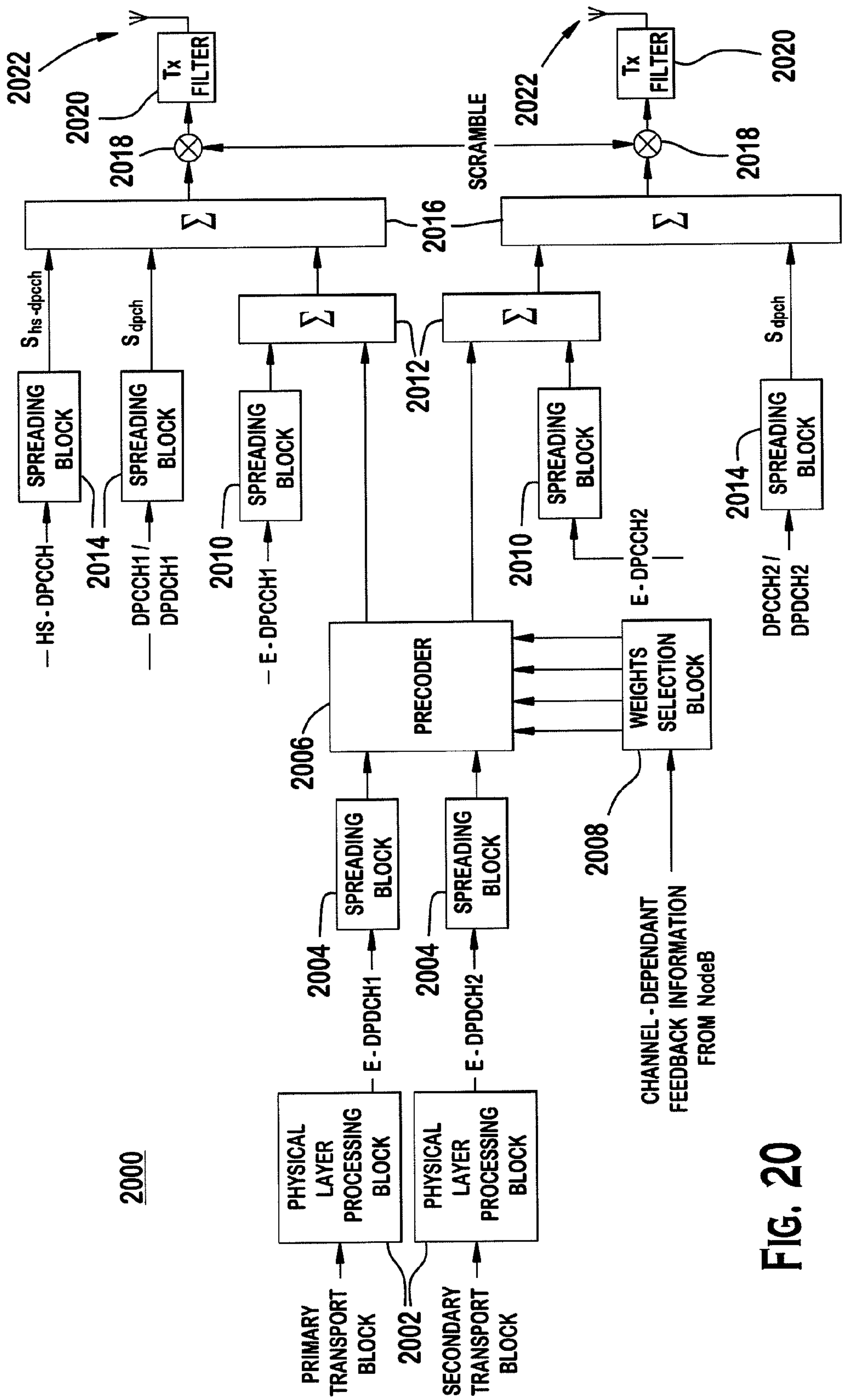

2000
PRIMARY TRANSPORT BLOCK
SECONDARY TRANSPORT BLOCK
2002
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
E-DPDCH1
E-DPDCH2
2004
SPREADING BLOCK
SPREADING BLOCK
2004
2006
PRECODER
WEIGHTS SELECTION BLOCK
2008
CHANNEL-DEPENDANT FEEDBACK INFORMATION FROM NodeB
HS-DPCCH
DPCCH1 / DPDCH1
E-DPCCH1
E-DPCCH2
DPCCH2 / DPDCH2
2014
2010
2010
2014
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
$S_{hs\text{-}dpcch}$
S_{dpch}
S_{dpch}
2012
Σ
Σ
Σ
Σ
2016
SCRAMBLE
2018
2018
2020
2020
Tx FILTER
Tx FILTER
2022
2022

FIG. 20

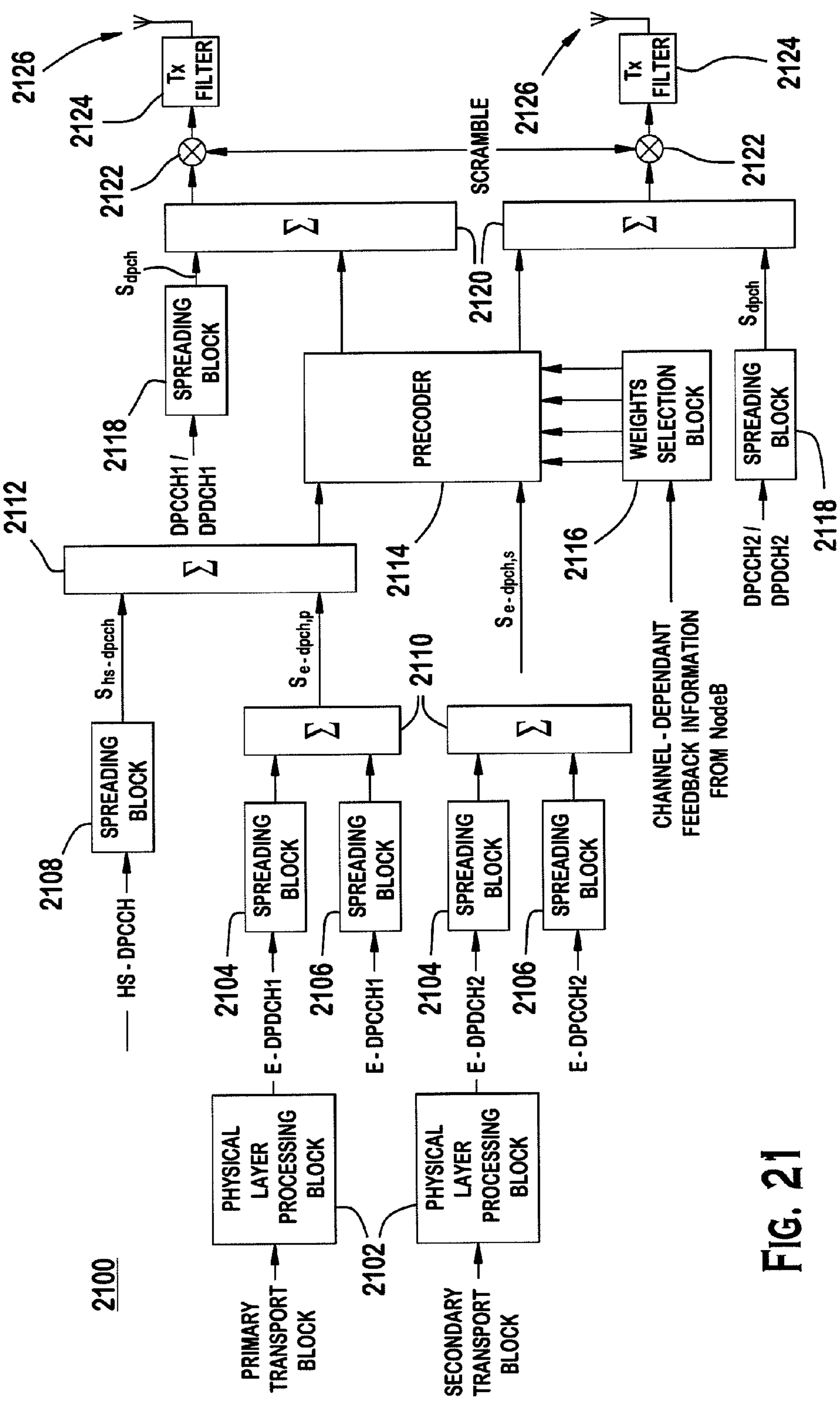

2100
PRIMARY TRANSPORT BLOCK
SECONDARY TRANSPORT BLOCK
2102
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
E-DPDCH1
E-DPCCH1
E-DPDCH2
E-DPCCH2
HS-DPCCH
2104
2106
2108
SPREADING BLOCK
2110
$S_{hs-dpcch}$
$S_{e-dpch,p}$
$S_{e-dpch,s}$
2112
2114
PRECODER
2116
WEIGHTS SELECTION BLOCK
CHANNEL-DEPENDANT FEEDBACK INFORMATION FROM NodeB
DPCCH1 / DPDCH1
DPCCH2 / DPDCH2
2118
S_{dpch}
2120
SCRAMBLE
2122
2124
Tx FILTER
2126

FIG. 21

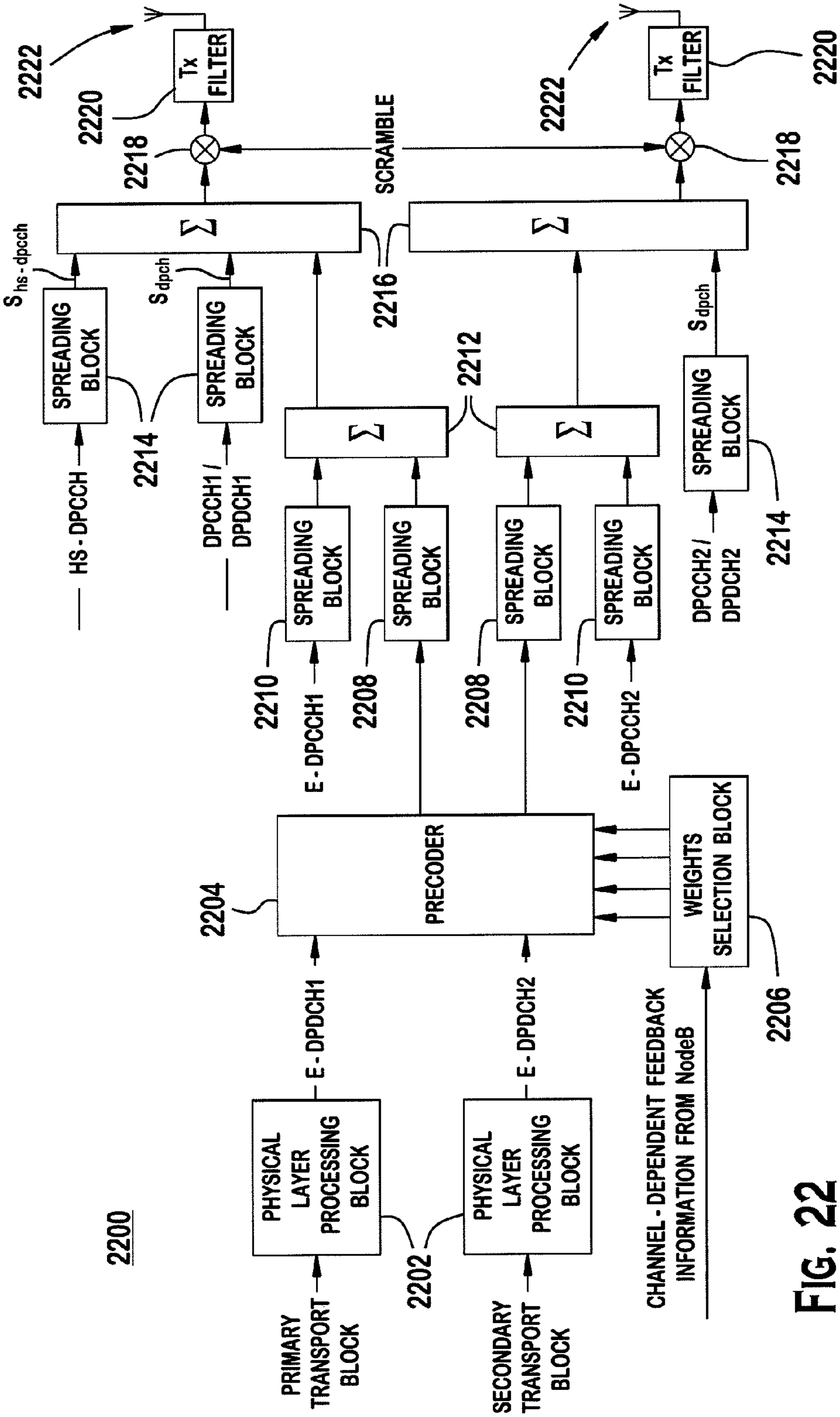

2200
PRIMARY TRANSPORT BLOCK
SECONDARY TRANSPORT BLOCK
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
2202
E - DPDCH1
E - DPDCH2
CHANNEL - DEPENDENT FEEDBACK INFORMATION FROM NodeB
PRECODER
2204
WEIGHTS SELECTION BLOCK
2206
E - DPCCH1
E - DPCCH2
2210
2208
2208
2210
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
2212
HS - DPCCH
DPCCH1 / DPDCH1
DPCCH2 / DPDCH2
SPREADING BLOCK
SPREADING BLOCK
SPREADING BLOCK
2214
2214
$S_{hs-dpcch}$
S_{dpch}
S_{dpch}
2216
SCRAMBLE
2218
2218
Tx FILTER
Tx FILTER
2220
2220
2222
2222

FIG. 22

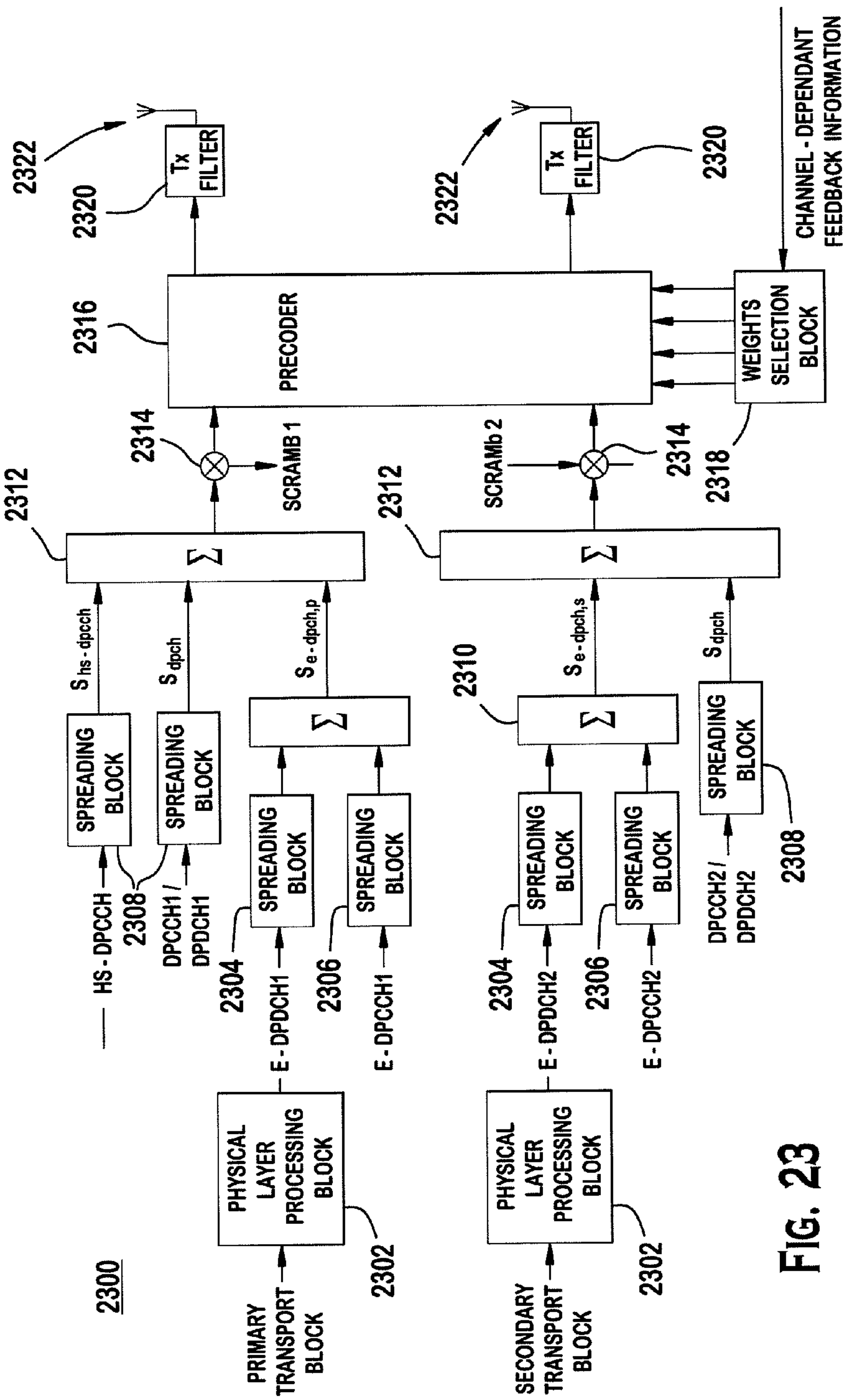

2300
PRIMARY TRANSPORT BLOCK
PHYSICAL LAYER PROCESSING BLOCK
2302
E - DPDCH1
E - DPCCH1
2304
2306
SPREADING BLOCK
HS - DPCCH
DPCCH1 / DPDCH1
2308
$S_{hs-dpcch}$
S_{dpch}
$S_{e-dpch,p}$
Σ
2312
SCRAMB 1
2314
2316
PRECODER
2320
Tx FILTER
2322
SECONDARY TRANSPORT BLOCK
E - DPDCH2
E - DPCCH2
DPCCH2 / DPDCH2
2310
$S_{e-dpch,s}$
SCRAMb 2
2318
WEIGHTS SELECTION BLOCK
CHANNEL - DEPENDANT FEEDBACK INFORMATION FROM NodeB

FIG. 23

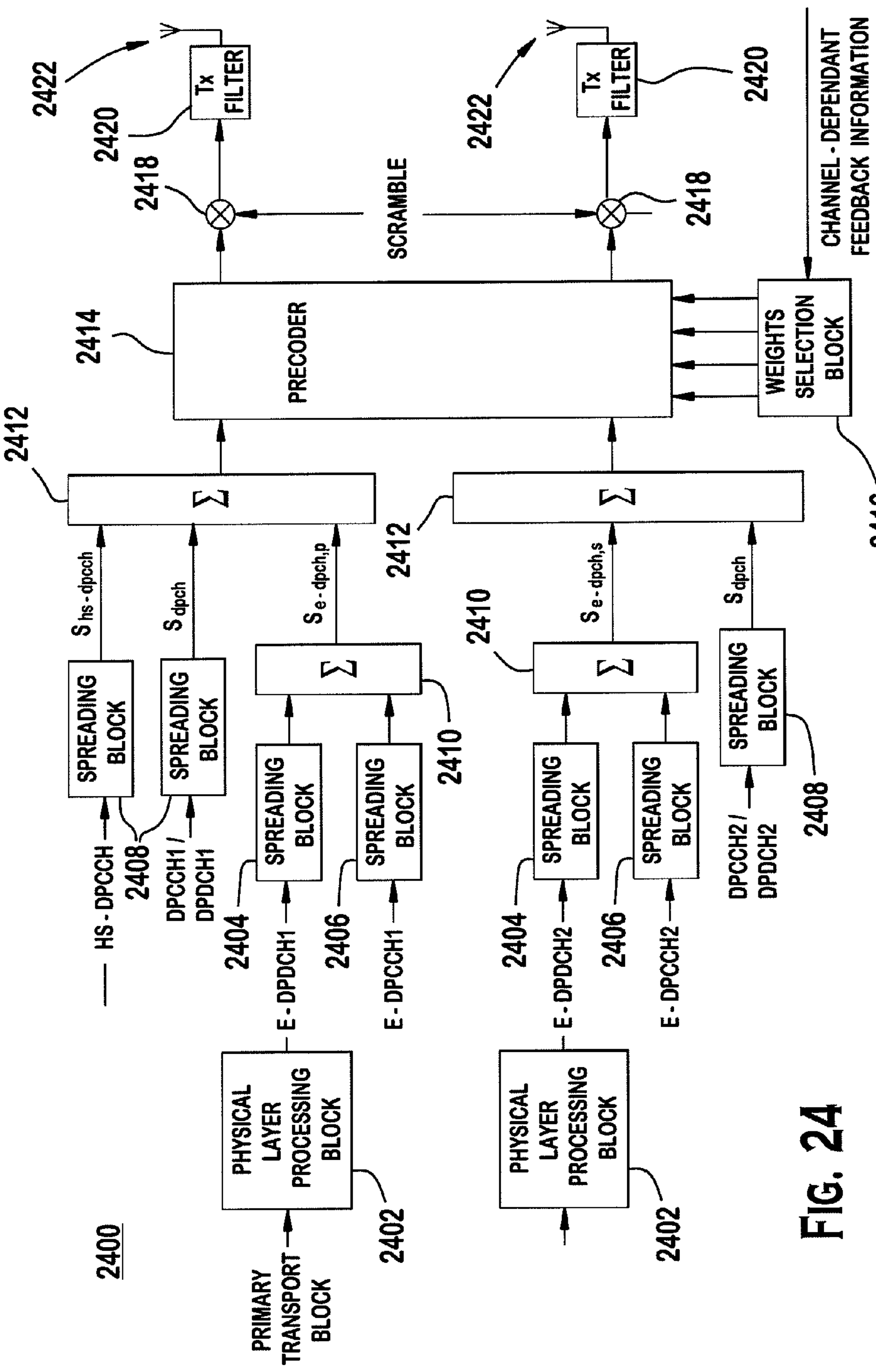

2400
PRIMARY TRANSPORT BLOCK
PHYSICAL LAYER PROCESSING BLOCK
2402
E-DPDCH1
E-DPCCH1
2404
2406
SPREADING BLOCK
2410
Σ
$S_{e\text{-}dpch,p}$
HS-DPCCH
DPCCH1 / DPDCH1
2408
$S_{hs\text{-}dpcch}$
S_{dpch}
2412
PRECODER
2414
SCRAMBLE
2418
2420
Tx FILTER
2422
E-DPDCH2
E-DPCCH2
DPCCH2 / DPDCH2
$S_{e\text{-}dpch,s}$
WEIGHTS SELECTION BLOCK
2416
CHANNEL-DEPENDANT FEEDBACK INFORMATION FROM NodeB

FIG. 24

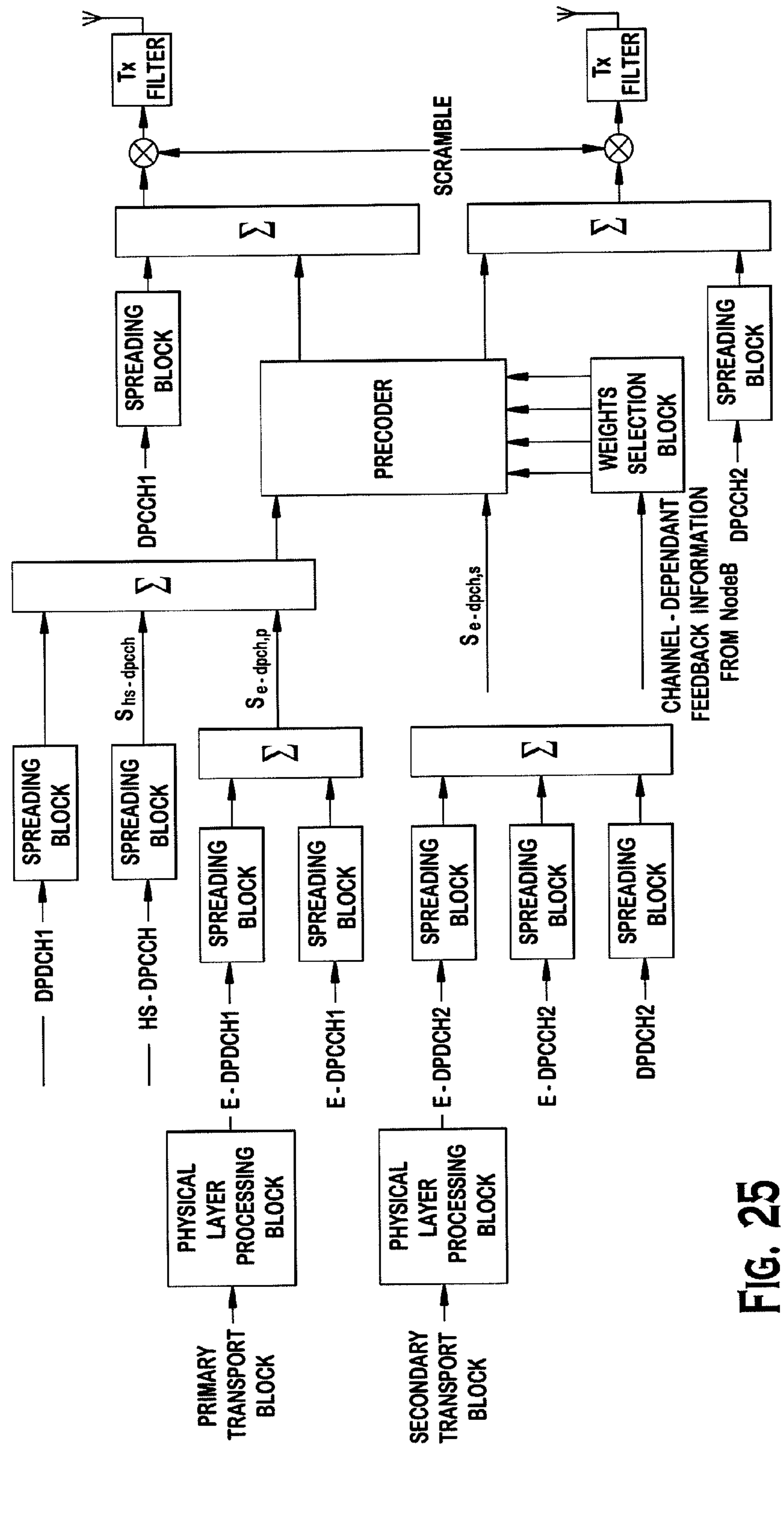

PRIMARY TRANSPORT BLOCK
SECONDARY TRANSPORT BLOCK
PHYSICAL LAYER PROCESSING BLOCK
PHYSICAL LAYER PROCESSING BLOCK
DPDCH1
HS-DPCCH
E-DPDCH1
E-DPCCH1
E-DPDCH2
E-DPCCH2
DPDCH2
SPREADING BLOCK
Σ
$S_{hs-dpcch}$
$S_{e-dpch,p}$
$S_{e-dpch,s}$
CHANNEL-DEPENDANT FEEDBACK INFORMATION FROM NodeB
DPCCH1
DPCCH2
PRECODER
WEIGHTS SELECTION BLOCK
SCRAMBLE
Tx FILTER

FIG. 25

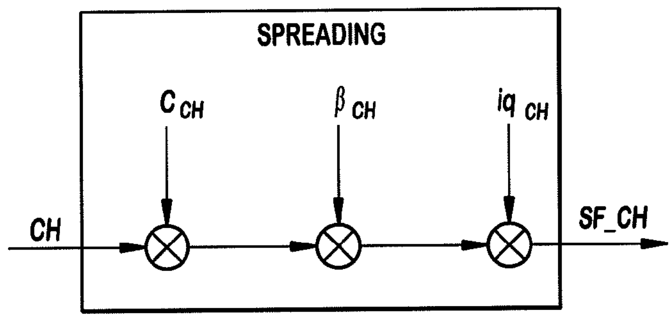

SPREADING
C_{CH}
β_{CH}
iq_{CH}
CH
SF_CH

FIG. 26

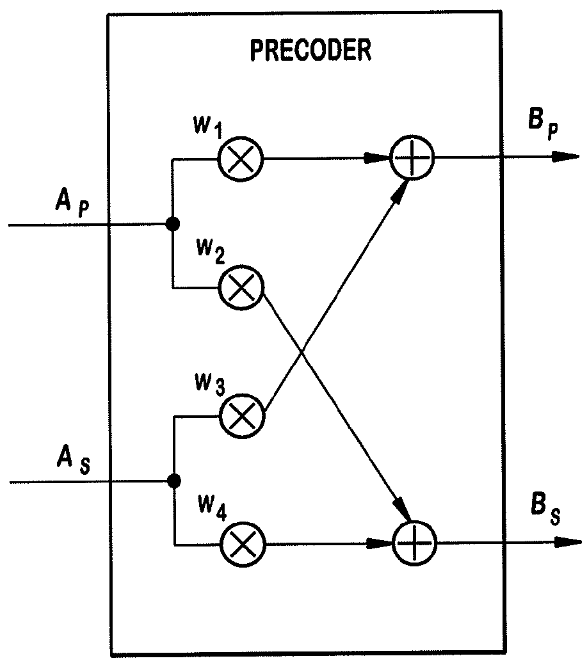

PRECODER
W_1
W_2
W_3
W_4
A_P
A_S
B_P
B_S

FIG. 27

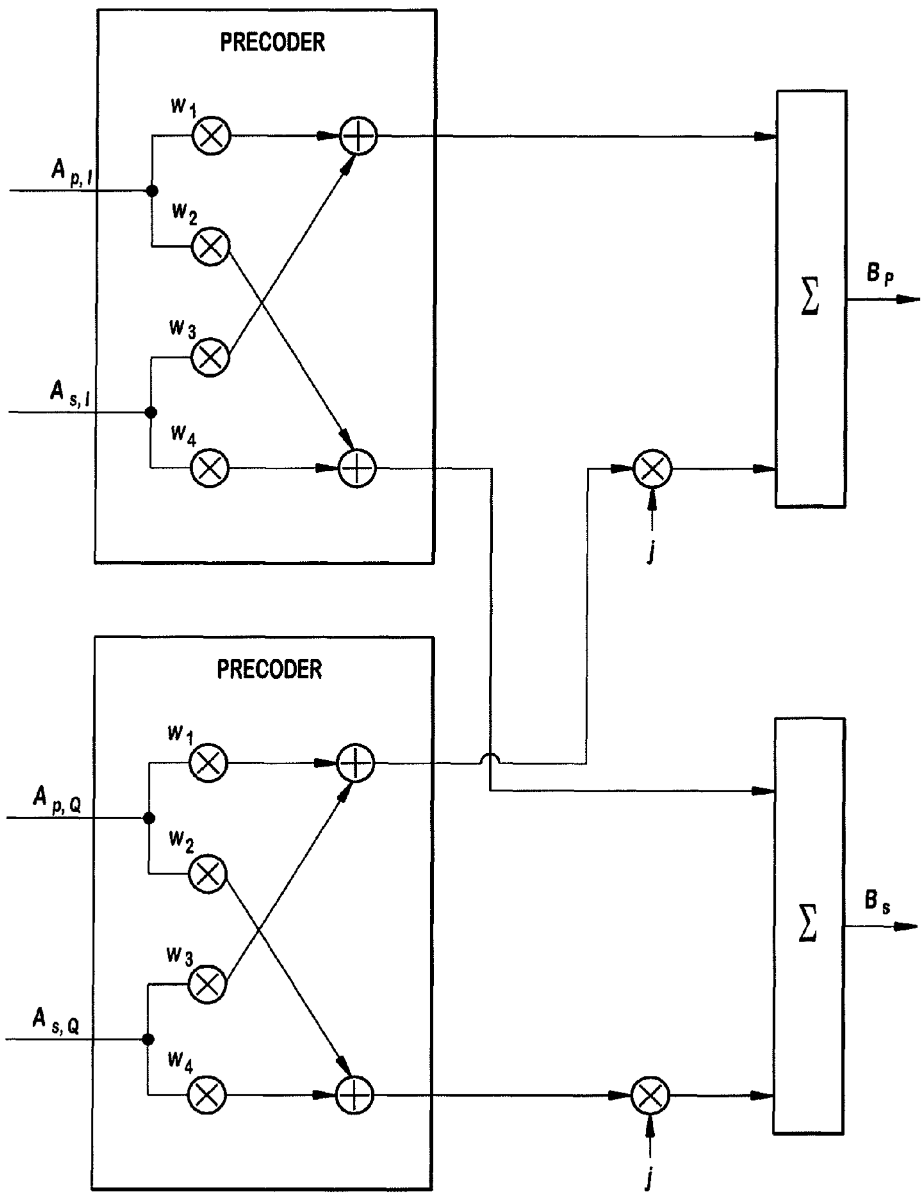

PRECODER
w_1
w_2
w_3
w_4
$A_{p,I}$
$A_{s,I}$
PRECODER
w_1
w_2
w_3
w_4
$A_{p,Q}$
$A_{s,Q}$
Σ
B_P
Σ
B_s
j
j

FIG. 28

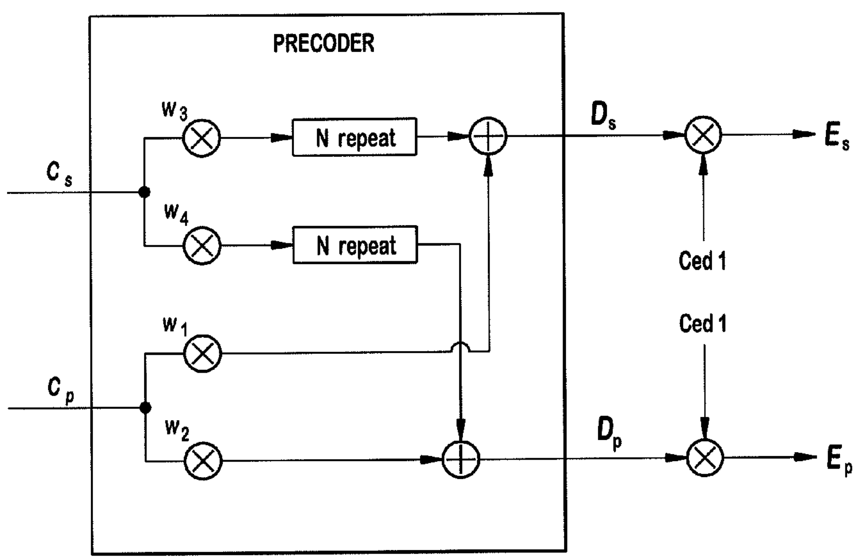
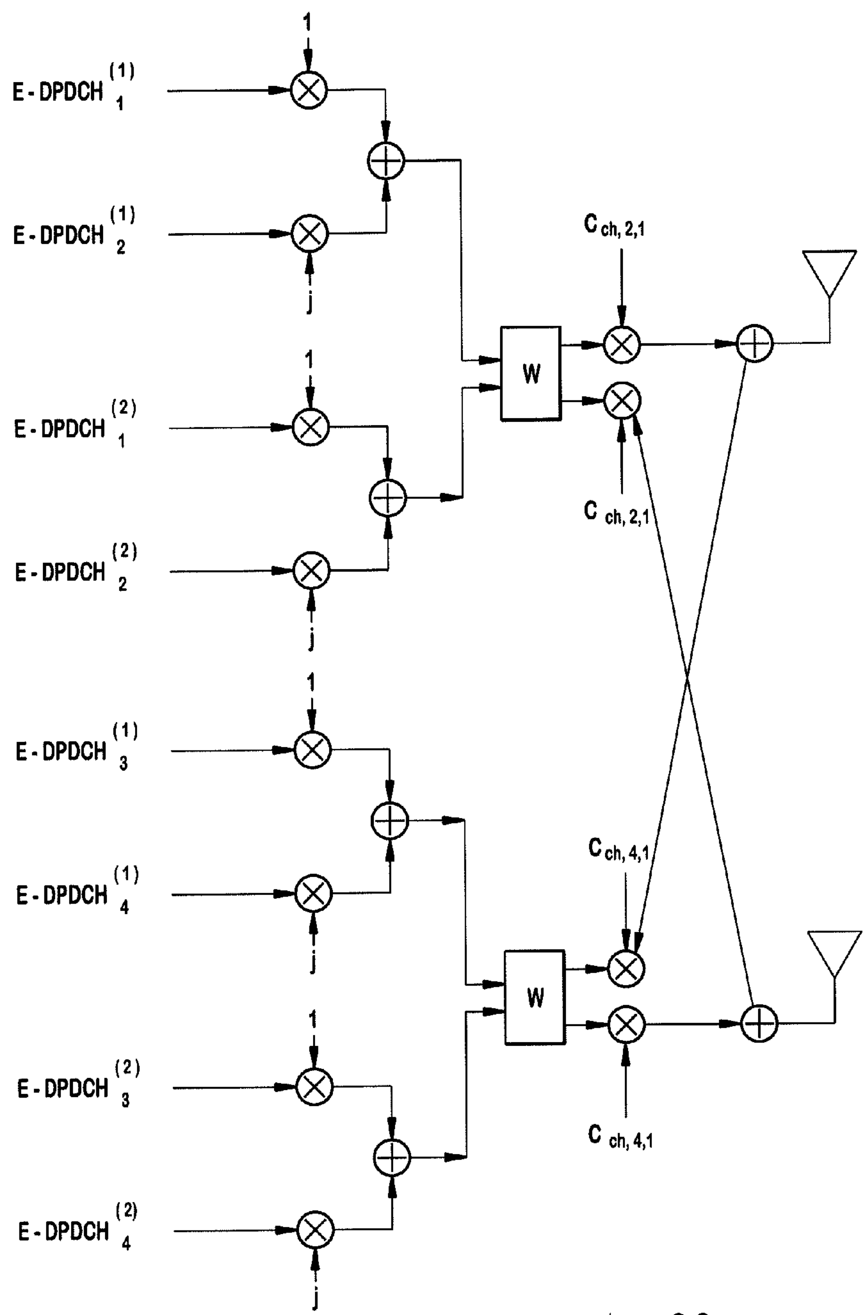

PRECODER
w_3
N repeat
w_4
N repeat
w_1
w_2
C_s
C_p
D_s
D_p
E_s
E_p
Ced 1
Ced 1

FIG. 29



E-DPDCH $^{(1)}_{1}$
E-DPDCH $^{(1)}_{2}$
E-DPDCH $^{(2)}_{1}$
E-DPDCH $^{(2)}_{2}$
E-DPDCH $^{(1)}_{3}$
E-DPDCH $^{(1)}_{4}$
E-DPDCH $^{(2)}_{3}$
E-DPDCH $^{(2)}_{4}$
1
j
W
$C_{ch,2,1}$
$C_{ch,4,1}$

FIG. 30

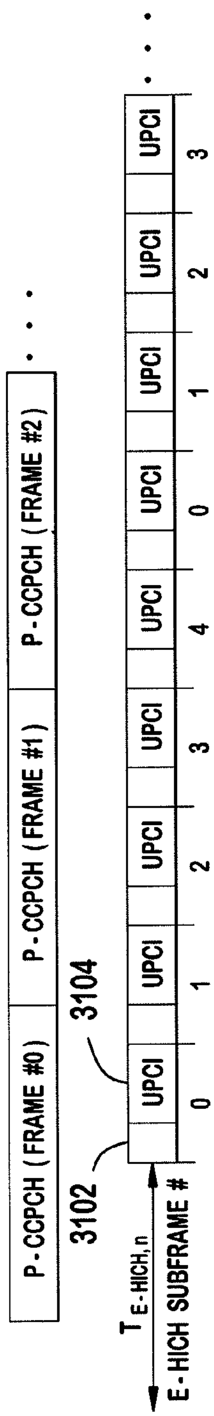


FIG. 31A

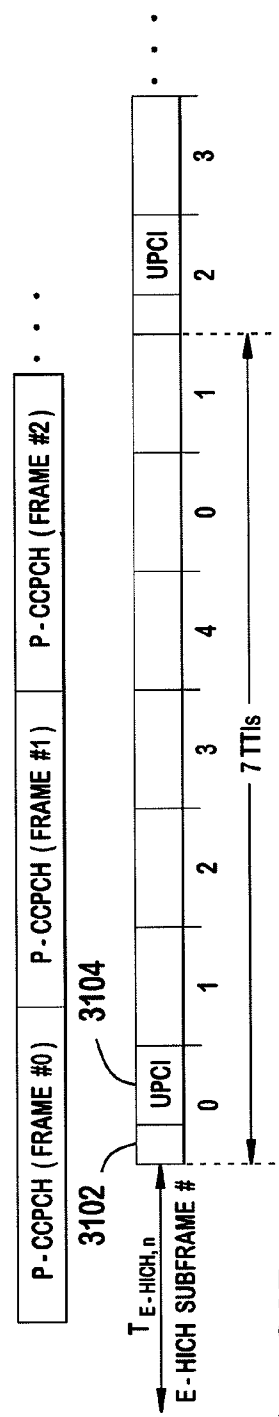


FIG. 31B

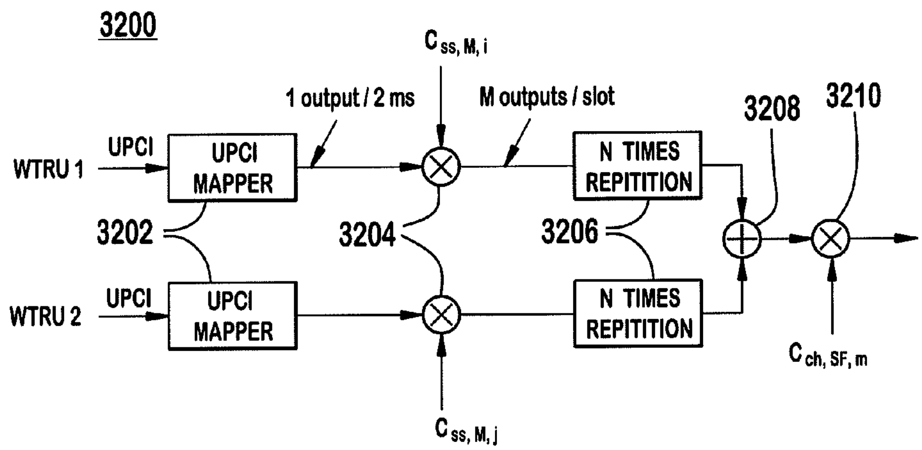

3200
1 output / 2 ms
M outputs / slot
3208
3210
WTRU 1
UPCI
UPCI MAPPER
N TIMES REPITITION
3202
3204
3206
WTRU 2
UPCI
UPCI MAPPER
N TIMES REPITITION

FIG. 32

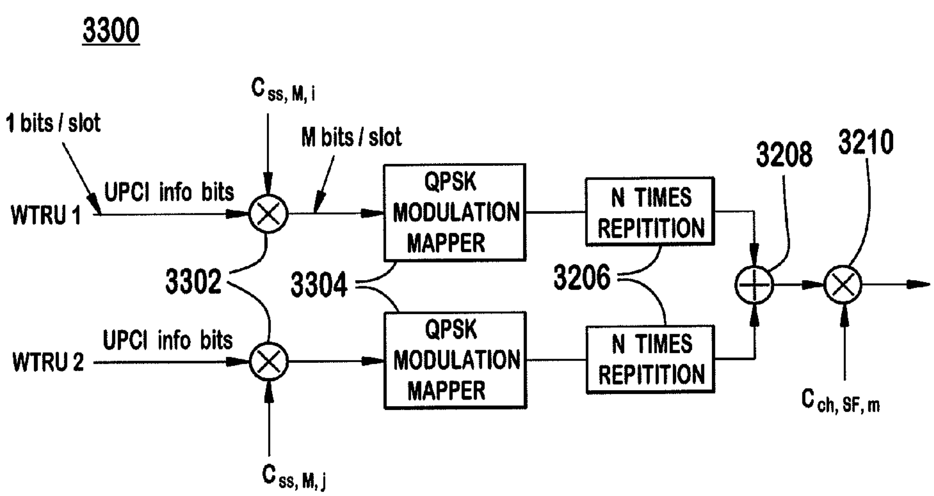

3300
1 bits / slot
M bits / slot
3208
3210
WTRU 1
UPCI info bits
QPSK MODULATION MAPPER
N TIMES REPITITION
3302
3304
3206
WTRU 2
UPCI info bits
QPSK MODULATION MAPPER
N TIMES REPITITION

FIG. 33

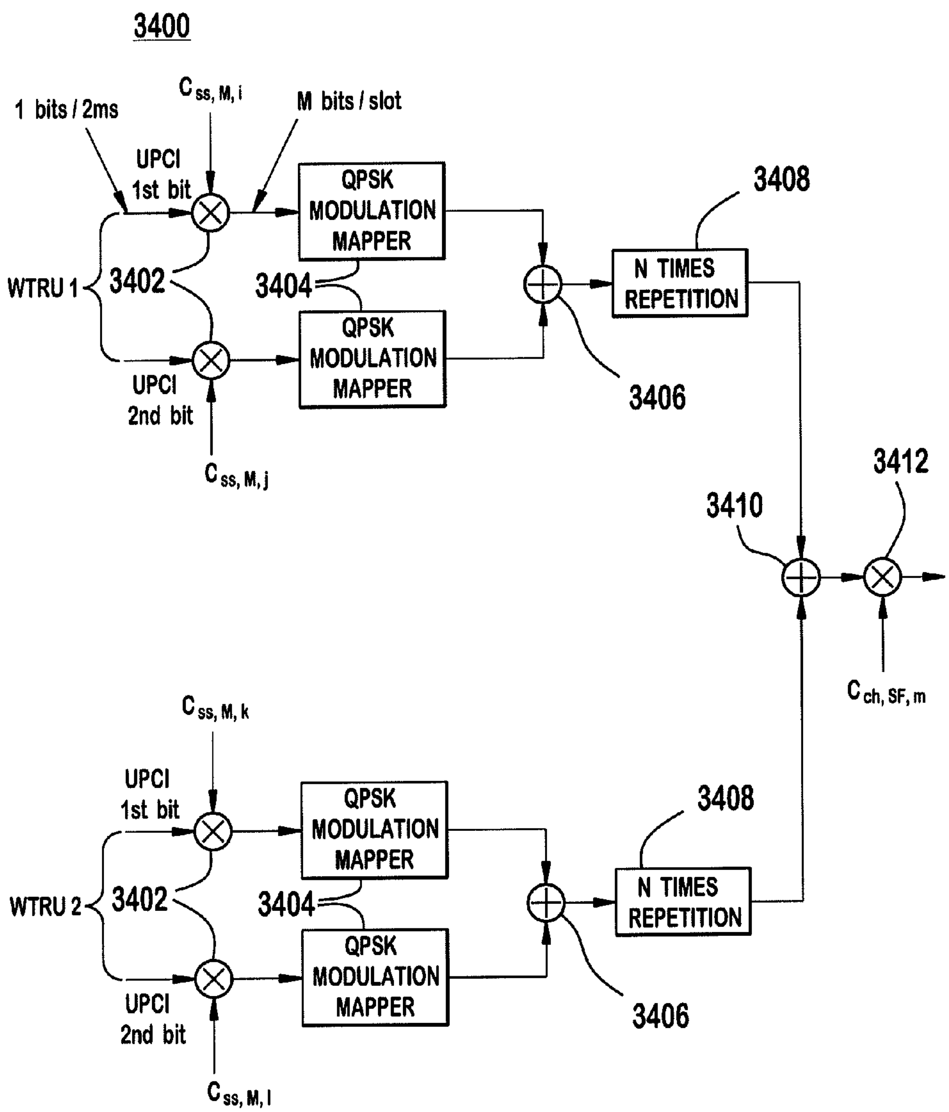

3400
1 bits / 2ms
$C_{ss,M,i}$
M bits / slot
UPCI
1st bit
QPSK
MODULATION
MAPPER
3408
WTRU 1
3402
3404
N TIMES
REPETITION
QPSK
MODULATION
MAPPER
UPCI
2nd bit
3406
$C_{ss,M,j}$
3410
3412
$C_{ch,SF,m}$
$C_{ss,M,k}$
UPCI
1st bit
QPSK
MODULATION
MAPPER
3408
WTRU 2
3402
3404
N TIMES
REPETITION
QPSK
MODULATION
MAPPER
UPCI
2nd bit
3406
$C_{ss,M,l}$

FIG. 34

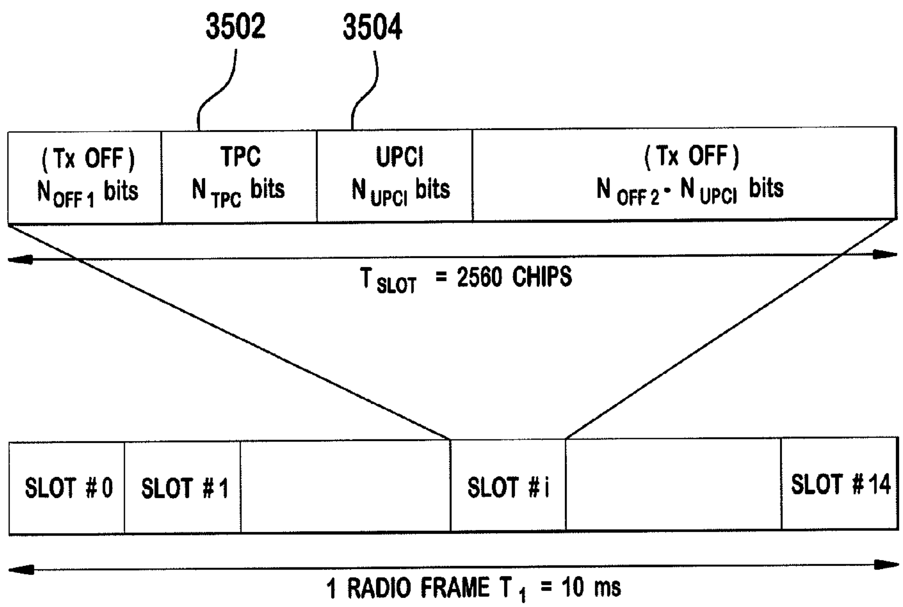

3502
3504
(Tx OFF)
$N_{OFF\,1}$ bits
TPC
N_{TPC} bits
UPCI
N_{UPCI} bits
(Tx OFF)
$N_{OFF\,2}$ - N_{UPCI} bits
T_{SLOT} = 2560 CHIPS
SLOT # 0
SLOT # 1
SLOT # i
SLOT # 14
1 RADIO FRAME T_1 = 10 ms

FIG. 35

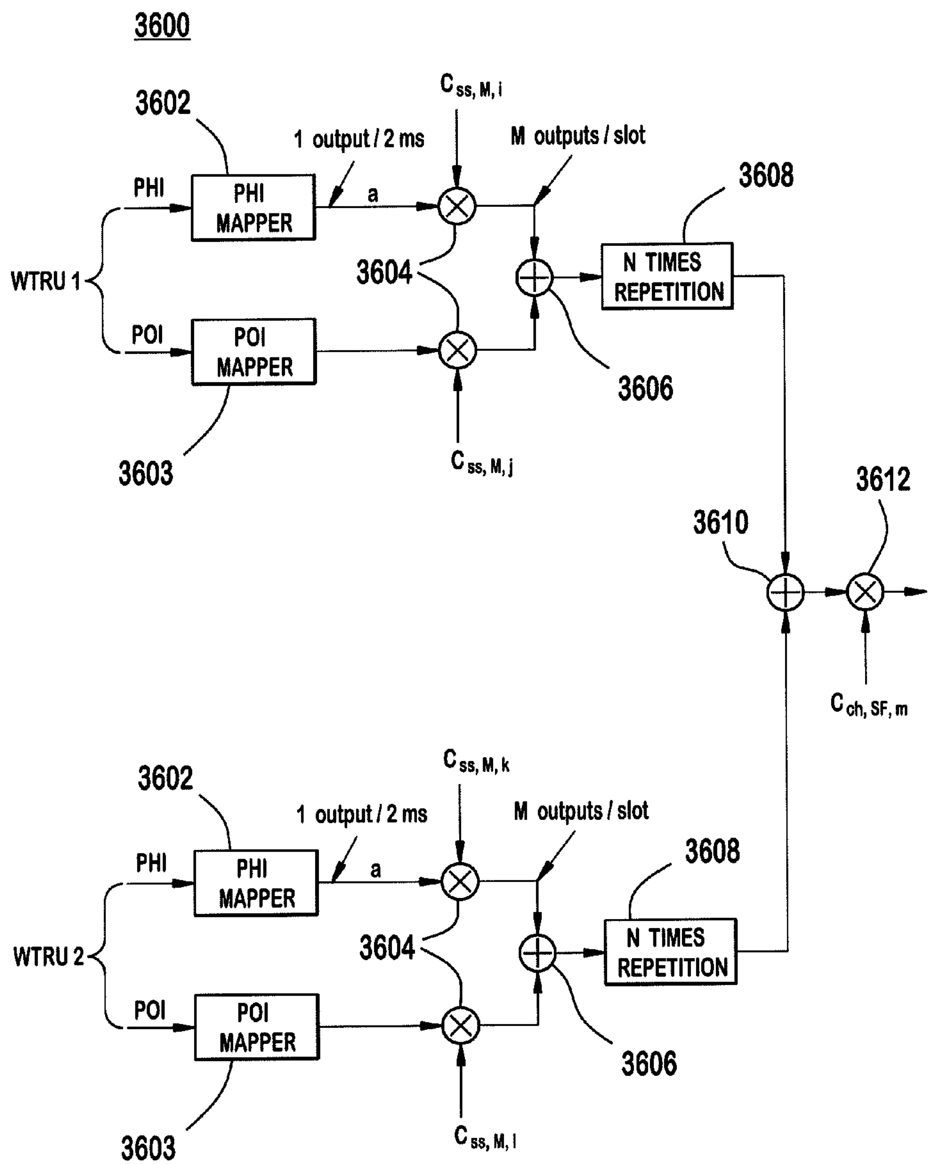

3600
3602
PHI
PHI MAPPER
1 output / 2 ms
a
$C_{ss, M, i}$
M outputs / slot
3608
N TIMES REPETITION
WTRU 1
3604
POI
POI MAPPER
3606
3603
$C_{ss, M, j}$
3610
3612
$C_{ch, SF, m}$
3602
PHI
PHI MAPPER
1 output / 2 ms
a
$C_{ss, M, k}$
M outputs / slot
3608
N TIMES REPETITION
WTRU 2
3604
POI
POI MAPPER
3606
3603
$C_{ss, M, l}$

FIG. 36

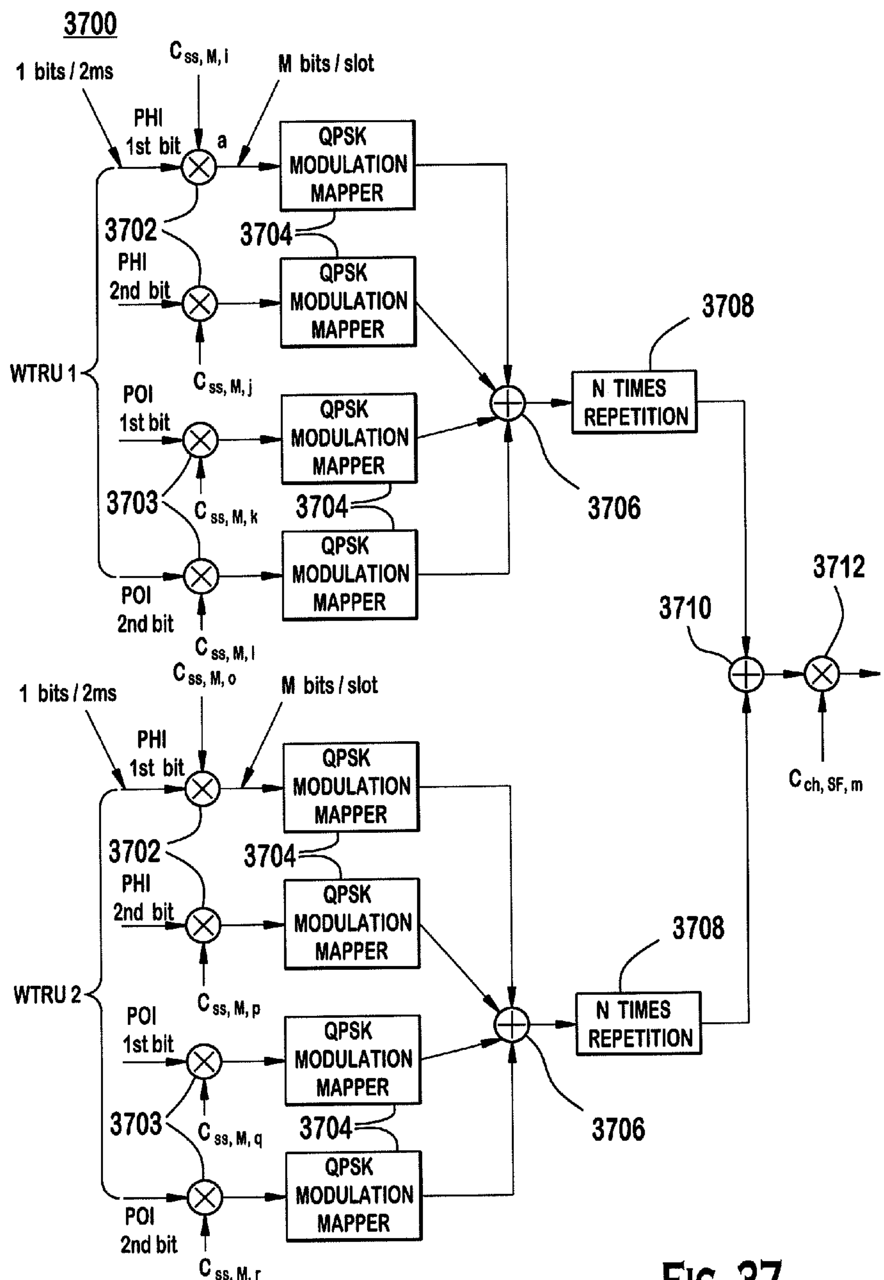
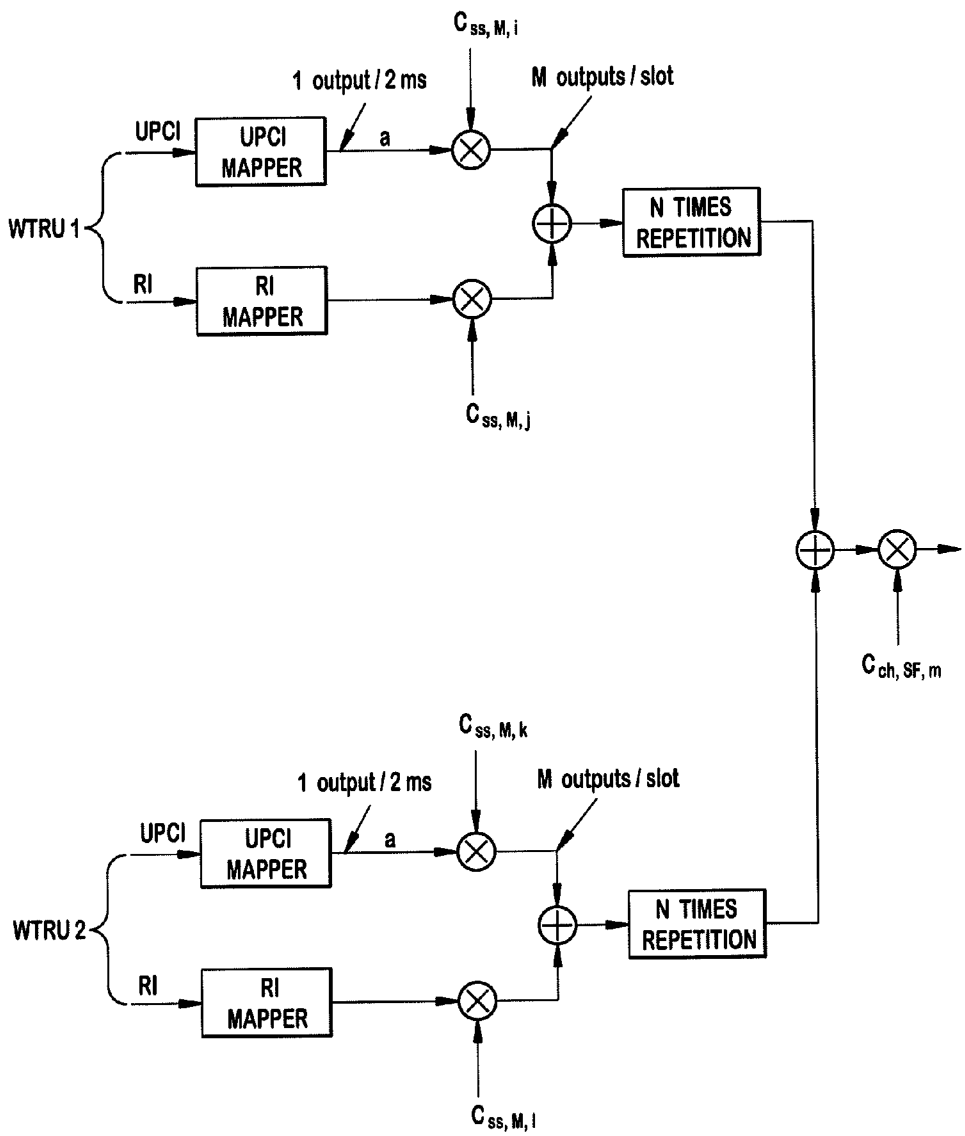

3700
1 bits / 2ms
$C_{ss, M, i}$
M bits / slot
PHI 1st bit
a
QPSK MODULATION MAPPER
3702
3704
PHI 2nd bit
QPSK MODULATION MAPPER
$C_{ss, M, j}$
3708
WTRU 1
POI 1st bit
QPSK MODULATION MAPPER
N TIMES REPETITION
3703
$C_{ss, M, k}$
3704
3706
QPSK MODULATION MAPPER
POI 2nd bit
$C_{ss, M, l}$
3712
3710
$C_{ss, M, o}$
1 bits / 2ms
M bits / slot
PHI 1st bit
QPSK MODULATION MAPPER
$C_{ch, SF, m}$
3702
3704
PHI 2nd bit
QPSK MODULATION MAPPER
3708
WTRU 2
$C_{ss, M, p}$
POI 1st bit
QPSK MODULATION MAPPER
N TIMES REPETITION
3703
$C_{ss, M, q}$
3704
3706
QPSK MODULATION MAPPER
POI 2nd bit
$C_{ss, M, r}$

FIG. 37



$C_{ss,M,i}$
1 output / 2 ms
M outputs / slot
UPCI
UPCI MAPPER
a
WTRU 1
N TIMES REPETITION
RI
RI MAPPER
$C_{ss,M,j}$
$C_{ch,SF,m}$
$C_{ss,M,k}$
1 output / 2 ms
M outputs / slot
UPCI
UPCI MAPPER
a
WTRU 2
N TIMES REPETITION
RI
RI MAPPER
$C_{ss,M,l}$

FIG. 38

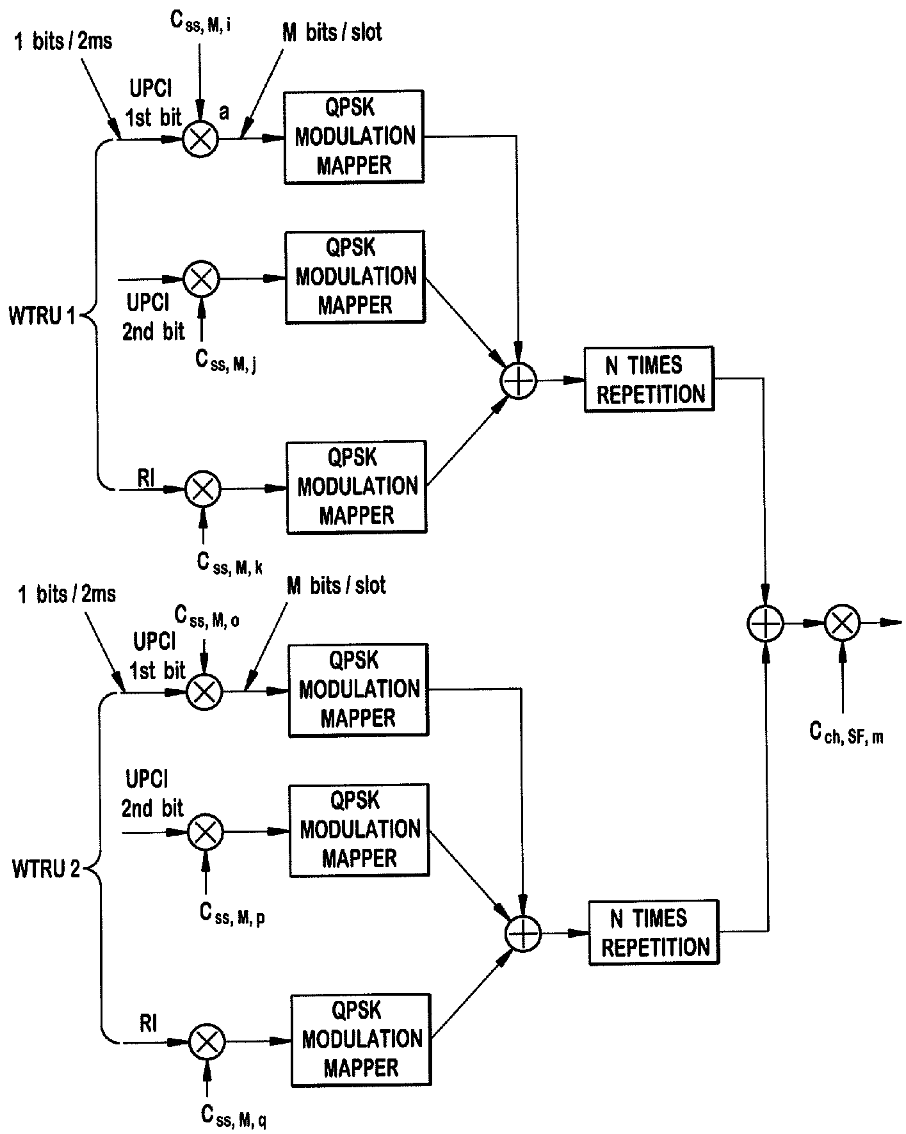
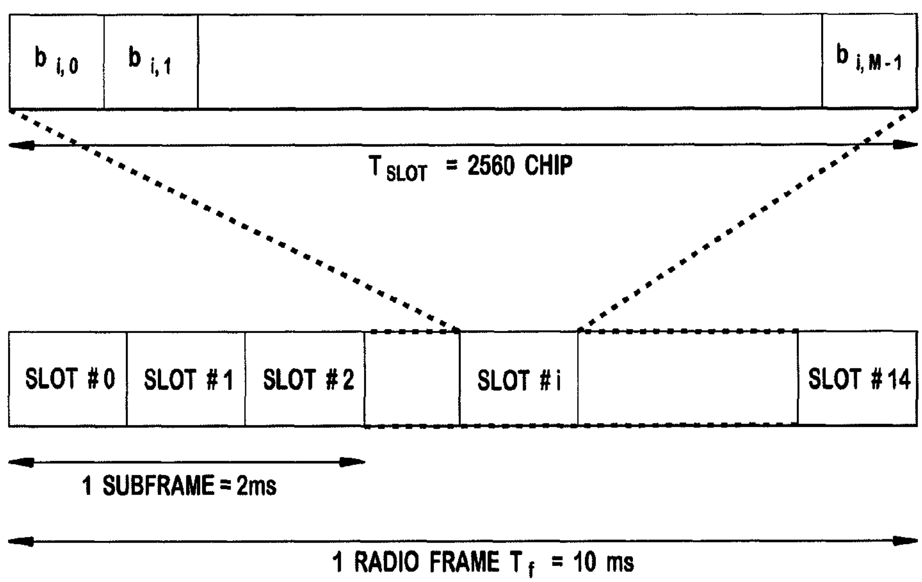

1 bits / 2ms
$C_{ss,M,i}$
M bits / slot
UPCI
1st bit
a
QPSK MODULATION MAPPER
QPSK MODULATION MAPPER
UPCI
2nd bit
WTRU 1
$C_{ss,M,j}$
N TIMES REPETITION
RI
QPSK MODULATION MAPPER
$C_{ss,M,k}$
1 bits / 2ms
M bits / slot
$C_{ss,M,o}$
UPCI
1st bit
QPSK MODULATION MAPPER
$C_{ch,SF,m}$
UPCI
2nd bit
QPSK MODULATION MAPPER
WTRU 2
$C_{ss,M,p}$
N TIMES REPETITION
RI
QPSK MODULATION MAPPER
$C_{ss,M,q}$

FIG. 39



$b_{i,0}$
$b_{i,1}$
$b_{i,M-1}$
T_{SLOT} = 2560 CHIP
SLOT #0
SLOT #1
SLOT #2
SLOT #i
SLOT #14
1 SUBFRAME = 2ms
1 RADIO FRAME T_f = 10 ms

FIG. 40

METHOD AND APPARATUS FOR MULTI-ANTENNA TRANSMISSION IN UPLINK

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/718,177, filed Dec. 18, 2012, which is a continuation of U.S. patent application Ser. No. 12/894,556, filed Sep. 30, 2010, which issued as U.S. Pat. No. 8,355,424 on Jan. 15, 2013, which claims the benefit of U.S. Provisional Application Nos. 61/247,123 filed Sep. 30, 2009; 61/248,313 filed Oct. 2, 2009; and 61/356,320 filed Jun. 18, 2010, the contents of which are hereby incorporated by reference herein.

BACKGROUND

Techniques for using multiple antennas have been used in cellular wireless communication systems as an effective means to improve robustness of data transmission and achieve higher data throughput. One of the multiple antenna techniques is space-time block coding (STBC). STBC is based on introducing joint correlations in transmitted signals in both the space and time domains to provide transmit diversity to combat fading channels.

The Alamouti scheme is the space-time block code to provide transmit diversity for systems with two transmit antennas. The Alamouti-based space-time block code has been widely used because of its simplicity and no need for the transmitter to know the channel state information (CSI) and therefore no need of channel feedback. Due to its effectiveness and easy implementation, the Alamouti-based space-time block code has been adopted into many wireless systems, such as WiMAX and WiFi. In third generation partnership project (3GPP), it was introduced in downlink transmissions in universal mobile telecommunication system (UMTS) since Release 99 and also adopted in downlink high speed downlink packet access (HSDPA) over higher speed data channels in Release 5. In the 3GPP standard, the implementation of Alamouti scheme is known as space time transmit diversity (STTD).

Enhanced uplink (EU), (also known as high speed uplink packet access (HSUPA)), is a feature that was introduced in 3GPP Release 6 to provide higher data rates in the uplink of UMTS wireless systems. The HSUPA may be configured to allow for much faster scheduling of uplink transmissions as well as lower overall data transmission latency.

Multiple antenna transmission/reception techniques with advanced signal processing are often referred to as multiple-input multiple-output (MIMO). MIMO has been widely studied and may significantly improve the performance of wireless communication systems.

Multiple antenna techniques have been widely adopted in many wireless communication systems such as IEEE 802.11n based wireless local area network access points and cellular systems like wideband code division multiple access (WCDMA)/high speed packet access (HSPA) and long term evolution (LTE). MIMO is introduced in WiMAX as well as in 3GPP. More advanced MIMO enhancements are currently being studied for 3GPP Release 9 and 10. Currently, only downlink (DL) MIMO is specified in 3GPP WCDMA standard.

SUMMARY

Method and apparatus for uplink transmission using multiple antennas are disclosed. A wireless transmit/receive unit (WTRU) performs space time transmit diversity (STTD) encoding on an input stream of a physical channel configured for STTD. Each physical channel may be mapped to either an in-phase (I) branch or a quadrature-phase (Q) branch. The STTD encoding generates a plurality of output streams such that the input stream is not changed for one output stream, and symbols of the input stream is switched and a constellation point of one symbol is changed to an opposite constellation point on an I branch or a Q branch for the other output stream. All configured physical channels on an I branch and a Q branch are combined, respectively, to generate a plurality of combined streams in a complex format, and the combined streams are transmitted via a plurality of antennas.

The physical channel configured for STTD may include at least one of an enhanced dedicated channel (E-DCH) dedicated physical data channel (E-DPDCH), an E-DCH dedicated physical control channel (E-DPCCH), a high speed dedicated physical control channel (HS-DPCCH), a dedicated physical control channel (DPCCH), and a dedicated physical data channel (DPDCH).

The WTRU may perform the STTD encoding either in a binary domain or in a complex domain. For the complex domain STTD encoding, the STTD encoding is performed on a block of complex-valued chips corresponding to one or an integer multiple of a largest spreading factor among the physical channels.

A WTRU may perform pre-coding on at least one type of uplink physical channel including the E-DPDCH with the pre-coding weights, and transmitting the pre-coded output streams via a plurality of antennas. Either multiple E-DPDCH data streams may be transmitted using multiple-input multiple-output (MIMO) or a single E-DPDCH data stream may be transmitted using a closed loop transmit diversity depending on the E-DPDCH configuration. The pre-coding may be performed either after or before the spreading operation.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

FIG. **1**A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

FIG. **1**B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. **1**A;

FIG. **1**C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. **1**A;

FIG. **2** shows an STTD transmitter in accordance with one embodiment;

FIG. **3** shows an STTD transmitter in accordance with another embodiment;

FIG. **4** shows an STTD transmitter in accordance with another embodiment;

FIG. **5** shows an STTD transmitter in accordance with another embodiment;

FIG. **6** shows an STTD transmitter in accordance with another embodiment;

FIG. **7** shows an STTD transmitter in accordance with another embodiment;

FIG. **8** shows an STTD transmitter in accordance with another embodiment;

FIGS. **9**(A)-**9**(D) show transmission schemes for the non-STTD channel(s);

FIGS. **10**(A) and **10**(B) show example binary STTD encoders for binary phase shift keying (BPSK) modulated data transmission;

FIGS. **11**(A) and **11**(B) show example STTD encoders for 4-level pulse amplitude modulation (4PAM) modulation;

FIGS. **12**(A) and **12**(B) show example STTD encoders for 8PAM;

FIG. **13** shows an example transmitter structure with a dual binary STTD encoder;

FIG. **14** shows an example STTD transmitter with a complex STTD encoder;

FIG. **15** shows an example complex STTD encoding process;

FIG. **16** shows STTD symbol configuration with different spreading factors (SFs);

FIG. **17** illustrates an exemplary complex STTD encoding applied to the HSUPA data channels;

FIG. **18** shows the corresponding block encoder in accordance with this embodiment;

FIG. **19** shows an example transmitter in accordance with one embodiment;

FIG. **20** shows an example transmitter in accordance with another embodiment;

FIG. **21** shows an example transmitter in accordance with another embodiment;

FIG. **22** shows an example transmitter in accordance with another embodiment;

FIG. **23** shows an example transmitter in accordance with another embodiment;

FIG. **24** shows an example transmitter in accordance with another embodiment;

FIG. **25** shows an example transmitter in accordance with another embodiment;

FIG. **26** shows the spreading operation, which includes spreading with a given channelization code, weighting, and IQ phase mapping;

FIG. **27** shows an example pre-coder for the dual stream case;

FIG. **28** shows another example pre-coder for the dual stream case;

FIG. **29** shows another example pre-coder for the dual stream case;

FIG. **30** shows an example transmitter for the two stream case;

FIG. **31**A shows an example UPCI signaling using an E-HICH;

FIG. **31**B illustrates the case where one out of seven E-HICH subframes carries the UPCI field;

FIG. **32** shows an example transmitter for transmitting uplink precoding control information (UPCI) for two WTRUs via an E-DCH channel state information channel (E-CSICH) in accordance with one embodiment;

FIG. **33** shows another example transmitter for transmitting UPCI for two WTRUs via an E-CSICH in accordance with another embodiment;

FIG. **34** shows another example transmitter for transmitting UPCI for two WTRUs via an E-CSICH in accordance with another embodiment;

FIG. **35** shows an F-DPCH format in accordance with this embodiment;

FIGS. **36** and **37** show signaling of PHI and POI using the transmitter structure shown in FIGS. **32** and **34**, respectively;

FIGS. **38** and **39** show signaling of UPCI and rank indication (RI) using the transmitter structure shown in FIGS. **32** and **34**, respectively;

FIG. **40** shows an example frame format for the E-CSICH.

DETAILED DESCRIPTION

FIG. **1**A is a diagram of an example communications system **100** in which one or more disclosed embodiments may be implemented. The communications system **100** may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system **100** may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems **100** may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

As shown in FIG. **1**A, the communications system **100** may include wireless transmit/receive units (WTRUs) **102***a*, **102***b*, **102***c*, **102***d*, a radio access network (RAN) **104**, a core network **106**, a public switched telephone network (PSTN) **108**, the Internet **110**, and other networks **112**, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

The communications systems **100** may also include a base station **114***a* and a base station **114***b*. Each of the base stations **114***a*, **114***b* may be any type of device configured to wirelessly interface with at least one of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* to facilitate access to one or more communication networks, such as the core network **106**, the Internet **110**, and/or the networks **112**. By way of example, the base stations **114***a*, **114***b* may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations **114***a*, **114***b* are each depicted as a single element, it will be appreciated that the base stations **114***a*, **114***b* may include any number of interconnected base stations and/or network elements.

The base station **114***a* may be part of the RAN **104**, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station **114***a* and/or the base station **114***b* may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station **114***a* may be divided into three sectors. Thus, in one embodiment, the base station **114***a* may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station **114***a* may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

The base stations **114***a*, **114***b* may communicate with one or more of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* over an air interface **116**, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared

(IR), ultraviolet (UV), visible light, etc.). The air interface **116** may be established using any suitable radio access technology (RAT).

More specifically, as noted above, the communications system **100** may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station **114***a* in the RAN **104** and the WTRUs **102***a*, **102***b*, **102***c* may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface **116** using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

In another embodiment, the base station **114***a* and the WTRUs **102***a*, **102***b*, **102***c* may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface **116** using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

In other embodiments, the base station **114***a* and the WTRUs **102***a*, **102***b*, **102***c* may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

The base station **114***b* in FIG. **1**A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. **1**A, the base station **114***b* may have a direct connection to the Internet **110**. Thus, the base station **114***b* may not be required to access the Internet **110** via the core network **106**.

The RAN **104** may be in communication with the core network **106**, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs **102***a*, **102***b*, **102***c*, **102***d*. For example, the core network **106** may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. **1**A, it will be appreciated that the RAN **104** and/or the core network **106** may be in direct or indirect communication with other RANs that employ the same RAT as the RAN **104** or a different RAT. For example, in addition to being connected to the RAN **104**, which may be utilizing an E-UTRA radio technology, the core network **106** may also be in communication with another RAN (not shown) employing a GSM radio technology.

The core network **106** may also serve as a gateway for the WTRUs **102***a*, **102***b*, **102***c*, **102***d* to access the PSTN **108**, the Internet **110**, and/or other networks **112**. The PSTN **108** may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet **110** may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks **112** may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks **112** may include another core network connected to one or more RANs, which may employ the same RAT as the RAN **104** or a different RAT.

Some or all of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* in the communications system **100** may include multi-mode capabilities, i.e., the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU **102***c* shown in FIG. **1**A may be configured to communicate with the base station **114***a*, which may employ a cellular-based radio technology, and with the base station **114***b*, which may employ an IEEE 802 radio technology.

FIG. **1**B is a system diagram of an example WTRU **102**. As shown in FIG. **1**B, the WTRU **102** may include a processor **118**, a transceiver **120**, a transmit/receive element **122**, a speaker/microphone **124**, a keypad **126**, a display/touchpad **128**, non-removable memory **106**, removable memory **132**, a power source **134**, a global positioning system (GPS) chipset **136**, and other peripherals **138**. It will be appreciated that the WTRU **102** may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

The processor **118** may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor **118** may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU **102** to operate in a wireless environment. The processor **118** may be coupled to the transceiver **120**, which may be coupled to the transmit/receive element **122**. While FIG. **1**B depicts the processor **118** and the transceiver **120** as separate components, it will be appreciated that the processor **118** and the transceiver **120** may be integrated together in an electronic package or chip.

The transmit/receive element **122** may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station **114***a*) over the air interface **116**. For example, in one embodiment, the transmit/receive element **122** may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element **122** may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element **122** may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element **122** may be configured to transmit and/or receive any combination of wireless signals.

In addition, although the transmit/receive element **122** is depicted in FIG. **1**B as a single element, the WTRU **102** may include any number of transmit/receive elements **122**. More specifically, the WTRU **102** may employ MIMO technology. Thus, in one embodiment, the WTRU **102** may include two or more transmit/receive elements **122** (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface **116**.

The transceiver **120** may be configured to modulate the signals that are to be transmitted by the transmit/receive element **122** and to demodulate the signals that are received by the transmit/receive element **122**. As noted above, the WTRU **102** may have multi-mode capabilities. Thus, the transceiver **120** may include multiple transceivers for enabling the WTRU **102** to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

The processor **118** of the WTRU **102** may be coupled to, and may receive user input data from, the speaker/microphone **124**, the keypad **126**, and/or the display/touchpad **128** (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor **118** may also output user data to the speaker/microphone **124**, the keypad **126**, and/or the display/touchpad **128**. In addition, the processor **118** may access information from, and store data in, any type of suitable memory, such as the non-removable memory **106** and/or the removable memory **132**. The non-removable memory **106** may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory **132** may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor **118** may access information from, and store data in, memory that is not physically located on the WTRU **102**, such as on a server or a home computer (not shown).

The processor **118** may receive power from the power source **134**, and may be configured to distribute and/or control the power to the other components in the WTRU **102**. The power source **134** may be any suitable device for powering the WTRU **102**. For example, the power source **134** may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

The processor **118** may also be coupled to the GPS chipset **136**, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU **102**. In addition to, or in lieu of, the information from the GPS chipset **136**, the WTRU **102** may receive location information over the air interface **116** from a base station (e.g., base stations **114***a*, **114***b*) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU **102** may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

The processor **118** may further be coupled to other peripherals **138**, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals **138** may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

FIG. **1**C is a system diagram of the RAN **104** and the core network **106** according to an embodiment. As noted above, the RAN **104** may employ a UTRA radio technology to communicate with the WTRUs **102***a*, **102***b*, **102***c* over the air interface **116**. The RAN **104** may also be in communication with the core network **106**. As shown in FIG. **1**C, the RAN **104** may include Node-Bs **140***a*, **140***b*, **140***c*, which may each include one or more transceivers for communicating with the WTRUs **102***a*, **102***b*, **102***c* over the air interface **116**. The Node-Bs **140***a*, **140***b*, **140***c* may each be associated with a particular cell (not shown) within the RAN **104**. The RAN **104** may also include RNCs **142***a*, **142***b*. It will be appreciated that the RAN **104** may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

As shown in FIG. **1**C, the Node-Bs **140***a*, **140***b* may be in communication with the RNC **142***a*. Additionally, the Node-B **140***c* may be in communication with the RNC **142***b*. The Node-Bs **140***a*, **140***b*, **140***c* may communicate with the respective RNCs **142***a*, **142***b* via an Iub interface. The RNCs **142***a*, **142***b* may be in communication with one another via an Iur interface. Each of the RNCs **142***a*, **142***b* may be configured to control the respective Node-Bs **140***a*, **140***b*, **140***c* to which it is connected. In addition, each of the RNCs **142***a*, **142***b* may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

The core network **106** shown in FIG. **1**C may include a media gateway (MGW) **144**, a mobile switching center (MSC) **146**, a serving GPRS support node (SGSN) **148**, and/or a gateway GPRS support node (GGSN) **150**. While each of the foregoing elements are depicted as part of the core network **106**, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

The RNC **142***a* in the RAN **104** may be connected to the MSC **146** in the core network **106** via an IuCS interface. The MSC **146** may be connected to the MGW **144**. The MSC **146** and the MGW **144** may provide the WTRUs **102***a*, **102***b*, **102***c* with access to circuit-switched networks, such as the PSTN **108**, to facilitate communications between the WTRUs **102***a*, **102***b*, **102***c* and traditional land-line communications devices.

The RNC **142***a* in the RAN **104** may also be connected to the SGSN **148** in the core network **106** via an IuPS interface. The SGSN **148** may be connected to the GGSN **150**. The SGSN **148** and the GGSN **150** may provide the WTRUs **102***a*, **102***b*, **102***c* with access to packet-switched networks, such as the Internet **110**, to facilitate communications between and the WTRUs **102***a*, **102***b*, **102***c* and IP-enabled devices.

As noted above, the core network **106** may also be connected to the networks **112**, which may include other wired or wireless networks that are owned and/or operated by other service providers.

It should be noted that although the embodiments will be described hereinafter in the context of 3GPP WCDMA, they are also applicable to any other wireless communication systems including, but not limited to, 3GPP LTE, LTE-Advanced, general packet radio services (GPRS), CDMA2000, WiMAX, WiFi, IEEE 802.x systems, and the like.

In 3GPP WCDMA, different uplink channels may be configured for different purposes and applications. A dedicated physical control channel (DPCCH) and a dedicated physical data channel (DPDCH) are the control and data channels introduced in Release 99. High speed downlink packet access (HSDPA) was introduced in Release 5, and a high speed dedicated physical control channel (HS-DPCCH) serves as a control channel for the HSDPA services. The HS-DPCCH carries channel quality indication and hybrid automatic repeat request (HARQ) acknowledgement. In Release 6, enhanced dedicated channel (E-DCH) services have been introduced. An E-DCH dedicated physical control channel (E-DPCCH) and an E-DCH dedicated physical data channel (E-DPDCH) are the control and data channels for E-DCH services. The DPCCH is used to enable channel estimation at the Node-Bs, to maintain a stable power control loop, and to provide baseline reference for all other channels in terms of error rate control and grant allocation.

The STTD encoding may be implemented with two or more transmit antennas, each of which may be associated with its own transmit chain including modulation mapper, spreader, I/Q combining, scrambler, and separate radio frontend. Hereafter, the embodiments will be explained with reference to the STTD transmitter with two transmit antennas. However, it should be noted that the embodiments may be extended to any number of transmit antennas and to any type of spatial diversity or spatial multiplexing multiple antenna transmission techniques.

The STTD encoder, as will be described in detail below, performs space-time processing over the data stream or signal to be transmitted and distributes its outputs to the two or more transmit chains. After the STTD encoder, the signals operate independently without interaction between the two or more transmit chains.

FIG. **2** shows an STTD transmitter **200** in accordance with one embodiment. In accordance with this embodiment, the STTD encoding may be applied to a high speed uplink data channel(s), (i.e., an E-DPDCH), and it may not be applied to other channels. The STTD transmitter **200** comprises a first physical layer processing block **202**, an STTD processing block **204**, second physical layer processing blocks **206**, third physical layer processing blocks **208**, channel combiners **210**, and scramblers **212**.

The first, second, and third physical layer processing blocks **202**, **206**, **208** may perform the conventional signal processing functions including modulation mapping, channelization code spreading, gain scaling, and I/Q combining, or any other functions. FIG. **2** shows that the STTD processing block **204** is placed between the first and second physical processing blocks **202**, **206**, but the STTD processing block **204** may be placed at any stage of the physical layer processing, and the functions performed by the first and second physical layer processing blocks **202**, **206** may be configured differently.

One or more E-DPDCHs may be configured for a WTRU. The E-DPDCH(s) is processed by the first physical layer processing block **202** and then processed by the STTD processing block **204**. The STTD processing block **204** outputs two or more signal streams depending on the number of transmit antennas. The STTD processing block **204** performs either binary STTD encoding or complex STTD encoding, and may perform the STTD encoding either on a bit/symbol level or on a block level, which will be explained in detail below. If multiple E-DPDCHs are configured, multiple E-DPDCHs may be processed individually or jointly depending on the STTD encoder structure. The physical channels, (i.e., E-DPDCHs), are initially formed as real valued and each physical channel may be mapped to either I branch or Q branch. At I/Q combining stage in the physical layer processing block (either the first physical layer processing block **202** or the second physical layer processing block **206**), the physical channels mapped to either the I branch or the Q branch to form complex signals. Non-STTD channels are processed by the third physical layer processing block(s) **208**. Which non-STTD channel is mapped to which transmit antenna is explained in detail below. The channel combining block **210** on each transmit path merges the signal streams from all the channels mapped to the corresponding antenna including the non-STTD channels and E-DPDCHs into a complex signal. The channel combined signal streams are then scrambled by scramblers **212** and transmitted via the antennas.

FIG. **3** shows an STTD transmitter **300** in accordance with another embodiment. In accordance with this embodiment, the STTD encoding is performed on HSUPA channels, (i.e., an E-DPDCH(s) and an E-DPCCH), and it may not be applied to other channels. The STTD transmitter **300** comprises first physical layer processing blocks **302***a*, **302***b*, STTD processing blocks **304***a*, **304***b*, second physical layer processing blocks **306***a*, **306***b*, third physical layer processing blocks **308**, channel combiners **310**, and scramblers **312**.

The first, second, and third physical layer processing blocks **302***a*/**302***b*, **306***a*, **306***b*, **308** may perform the conventional signal processing functions including modulation mapping, channelization code spreading, gain scaling, and I/Q combining, or any other functions. FIG. **3** shows that the STTD processing blocks **304***a*/**304***b* are placed between the first and second physical processing blocks **302***a*/**302***b* and **306***a*/**306***b*, but the STTD processing blocks **304***a*/**304***b* may be placed at any stage of the physical layer processing, and the functions performed by the first and second physical layer processing blocks **302***a*/**302***b*, **306***a*/**306***b* may be configured differently.

The E-DPCCH is processed by the first physical layer processing block **302***a* and then processed by the STTD processing block **304***a*. One or more E-DPDCHs may be configured for a WTRU. The E-DPDCH(s) is processed by the first physical layer processing block **302***b* and then processed by the STTD processing block **304***b*. Each of the STTD processing blocks **304***a*/**304***b* outputs two or more signal streams depending on the number of transmit antennas. The STTD processing blocks **304***a*/**304***b* perform either binary STTD encoding or complex STTD encoding, and may perform the STTD encoding either on a bit/symbol level or on a block level, which will be explained in detail below. If multiple E-DPDCHs are configured, multiple E-DPDCHs may be processed individually or jointly depending on the STTD encoder structure. The physical channels, (i.e., E-DPDCHs, E-DPCCH), are initially formed as real valued and each physical channel may be mapped to either I branch or Q branch. At I/Q combining stage in the physical layer processing block (either the first physical layer processing block **302***a*/**302***b* or the second physical layer processing block **306***a*/**306***b*), the physical channels are mapped to either the I branch or the Q branch to form complex signals. Non-STTD channels are processed by the third physical layer processing block(s) **308**. The channel combining block **310** on each transmit path merges the signal streams from all the channels mapped to the corresponding antenna including the non-STTD channels, E-DPDCHs, and E-DPCCH into a complex signal. The channel combined signal streams are then scrambled by scramblers **312** and transmitted via the antennas.

With the STTD transmitter of FIG. **3**, the reliability of the E-DPCCH associated with the high speed data channel is improved correspondingly by the transmit diversity. Thus, user throughput at cell edge will be enhanced without imposing the need of increasing the transmit power of the control channel. This may allow the E-DPCCH to have similar level of reliability with respect to the E-DPDCH.

FIG. **4** shows an STTD transmitter in accordance with another embodiment. In accordance with this embodiment, the STTD encoding is performed on the uplink control channels, (i.e., a DPCCH, an E-DPCCH, and an HS-DPCCH), and it may not be applied to other channels. The STTD transmitter **400** comprises first physical layer processing blocks **402***a*, 402*b*, 402*c*, STTD processing blocks 404*a*, 404*b*, 404*c*, second physical layer processing blocks 406*a*, 406*b*, 406*c*, third physical layer processing blocks 408, channel combiners 410, and scramblers 412.

The first, second, and third physical layer processing blocks 402*a*, 402*b*, 402*c*, 406*a*, 406*b*, 406*c*, 408 may perform the conventional signal processing functions including modulation mapping, channelization code spreading, gain scaling, and I/Q combining, or any other functions. FIG. 4 shows that the STTD processing blocks 404*a*/404*b*/404*c* are placed between the first and second physical processing blocks 402*a*/402*b*/402*c* and 406*a*/406*b*/406*c*, but the STTD processing block 404*a*, 404*b*, 404*c* may be placed at any stage of the physical layer processing, and the functions performed by the first and second physical layer processing blocks 402*a*/402*b*/402*c*, 406*a*/406*b*/406*c* may be configured differently.

The HS-DPCCH is processed by the first physical layer processing block 402*a* and then processed by the STTD processing block 404*a*. The DPCCH is processed by the first physical layer processing block 402*b* and then processed by the STTD processing block 404*b*. The DPCCH carries pilot symbols. Therefore, in accordance with this embodiment, the pilot symbols are also STTD encoded. The E-DPCCH is processed by the first physical layer processing block 402*c* and then processed by the STTD processing block 404*c*. Each of the STTD processing blocks 404*a*/404*b*/404*c* outputs two or more signal streams depending on the number of transmit antennas. The STTD processing blocks 404*a*/404*b*/404*c* perform either binary STTD encoding or complex STTD encoding, and may perform the STTD encoding either on a bit/symbol level or on a block level, which will be explained in detail below. The physical channels, (i.e., E-DPCCH, DPCCH, HS-DPCCH), are initially formed as real valued and each physical channel may be mapped to either I branch or Q branch. At I/Q combining stage in the physical layer processing block (either the first physical layer processing block 402*a*/402*b*/402*c* or the second physical layer processing block 406*a*/406*b*/406*c*), the physical channels are mapped to either the I branch or the Q branch to form complex signals. Non-STTD channels are processed by the third physical layer processing block(s) 408. The channel combining block 410 on each transmit path merges the signal streams from all the channels mapped to the corresponding antenna including the non-STTD channels, E-DPCCH, DPCCH, and HS-DPCCH into a complex signal. The channel combined signal streams are then scrambled by scramblers 412 and transmitted via the antennas.

FIG. 5 shows an STTD transmitter 500 in accordance with another embodiment. In accordance with this embodiment, the STTD encoding is performed on data channels, (i.e., a DPDCH(s), an E-DPDCH(s)), and it may not be applied to other channels. The STTD transmitter 500 comprises first physical layer processing blocks 502*a*, 502*b*, STTD processing blocks 504*a*, 504*b*, second physical layer processing blocks 506*a*, 506*b*, third physical layer processing blocks 508, channel combiners 510, and scramblers 512.

The first, second, and third physical layer processing blocks 502*a*, 502*b*, 506*a*, 506*b*, 508 may perform the conventional signal processing functions including modulation mapping, channelization code spreading, gain scaling, and I/Q combining, or any other functions. FIG. 5 shows that the STTD processing blocks 504*a*/504*b* are placed between the first and second physical processing blocks 502*a*/502*b* and 506*a*/506*b*, but the STTD processing blocks 504*a*/504*b* may be placed at any stage of the physical layer processing, and the functions performed by the first and second physical layer processing blocks 502*a*/502*b*, 506*a*/506*b* may be configured differently.

One or more DPDCH and/or one or more E-DPDCH(s) may be configured for a WTRU. The DPDCH(s) is processed by the first physical layer processing block 402*a* and then processed by the STTD processing block 404*a*. The E-DPDCH(s) is processed by the first physical layer processing block 402*b* and then processed by the STTD processing block 404*b*. Each of the STTD processing blocks 404*a*/404*b* outputs two or more signal streams depending on the number of transmit antennas. The STTD processing blocks 404*a*/404*b* perform either binary STTD encoding or complex STTD encoding, and may perform the STTD encoding either on a bit/symbol level or on a block level, which will be explained in detail below. If multiple DPDCHs and/or E-DPDCHs are configured, multiple DPDCHs and/or E-DPDCHs may be processed individually or jointly depending on the STTD encoder structure. The physical channels, (i.e., DPDCH(s) and E-DPDCH(s)), are initially formed as real valued and each physical channel may be mapped to either I branch or Q branch. At I/Q combining stage in the physical layer processing block (either the first physical layer processing block 502*a*/502*b* or the second physical layer processing block 506*a*/506*b*), the physical channels are mapped to either the I branch or the Q branch to form complex signals. Non-STTD channels are processed by the third physical layer processing block(s) 508. The channel combining block 510 on each transmit path merges the signal streams from all the channels mapped to the corresponding antenna including the non-STTD channels, DPDCH(s), and E-DPDCHs into a complex signal. The channel combined signal streams are then scrambled by scramblers 512 and transmitted via the antennas.

FIG. 6 shows an STTD transmitter 600 in accordance with another embodiment. In accordance with this embodiment, STTD encoding is performed on all uplink channels, (E-DPDCH(s), E-DPCCH, DPDCH(s), DPCCH, HS-DPCCH). The STTD transmitter 600 comprises first physical layer processing blocks 602*a*, 602*b*, 602*c*, 602*d*, 602*e*, STTD processing blocks 604*a*, 604*b*, 604*c*, 604*d*, 604*e*, second physical layer processing blocks 606*a*, 606*b*, 606*c*, 606*d*, 606*e*, channel combiners 610, and scramblers 612.

The first, second, and third physical layer processing blocks 602*a*, 602*b*, 602*c*, 602*d*, 602*e*, 606*a*, 606*b*, 606*c*, 606*d*, 606*e*, 608 may perform the conventional signal processing functions including modulation mapping, channelization code spreading, gain scaling, and I/Q combining, or any other functions. FIG. 6 shows that the STTD processing blocks 604*a*/604*b*/604*c*/606*d*/606*e* are placed between the first and second physical processing blocks 602*a*/602*b*/602*c*/602*d*/602*e* and 606*a*/606*b*/606*c*/606*d*/606*e*, but the STTD processing block 604*a*, 604*b*, 604*c*, 604*d*, 604*e* may be placed at any stage of the physical layer processing, and the functions performed by the first and second physical layer processing blocks 602*a*/602*b*/602*c*/602*d*/602*e*, 606*a*/606*b*/606*c*/606*d*/606*e* may be configured differently.

The E-DPCCH is processed by the first physical layer processing block 602*a* and then processed by the STTD processing block 604*a*. One or more DPDCH and/or one or more E-DPDCH(s) may be configured for a WTRU. The E-DPDCH(s) is processed by the first physical layer processing block 602*b* and then processed by the STTD processing block 604*b*. The DPCCH is processed by the first physical layer processing block 602*c* and then processed by the STTD processing block 604*c*. The DPCCH carries pilot symbols. Therefore, in accordance with this embodiment, the pilot symbols are also STTD encoded. The DPDCH(s) is processed by the first physical layer processing block **602***d* and then processed by the STTD processing block **604***d*. The HS-DPCCH is processed by the first physical layer processing block **602***e* and then processed by the STTD processing block **604***e*. Each of the STTD processing blocks **604***a*/**604***b*/**604***c*/**604***d*/**604***e* outputs two or more signal streams depending on the number of transmit antennas. The STTD processing blocks **604***a*/**604***b*/**604***c*/**604***d*/**604***e* perform either binary STTD encoding or complex STTD encoding, and may perform the STTD encoding either on a bit/symbol level or on a block level, which will be explained in detail below. The physical channels, (i.e., E-DPCCH, DPCCH, HS-DPCCH), are initially formed as real valued and each physical channel may be mapped to either I branch or Q branch. At I/Q combining stage in the physical layer processing block (either the first physical layer processing block **602***a*/**602***b*/**602***c*/**602***d*/**602***e* or the second physical layer processing block **606***a*/**606***b*/**606***c*/**606***d*/**606***e*), the physical channels are mapped to either the I branch or the Q branch to form complex signals. The channel combining block **610** on each transmit path merges the signal streams from all the channels mapped to the corresponding antenna including E-DPCCH, E-DPDCH(s), DPCCH, DPDCH(s), and HS-DPCCH into a complex signal. The channel combined signal streams are then scrambled by scramblers **612** and transmitted via the antennas.

The advantage of the STTD transmitter in FIG. **6** is that channels (both data and control channels) are all balanced in terms of the service quality therefore the power scaling configuration on each channel may be maintained the same as if no STTD is applied as long as the power control is performed properly according to the specified signal-to-interference ratio (SIR) or block error rate (BLER) target. Since the pilot signal transmitted in the DPCCH over the two antennas may be made orthogonal at the receiver with the appropriate STTD processing, the channel estimation at the Node-B may be readily conducted without introducing the second pilot signal.

The peak-to-average power ratio (PAPR) or the cubic metric of all the STTD transmitter structures disclosed above may maintain the similar level at each antenna as the conventional uplink implementation, since the STTD processing is applied per data symbol basis that does not introduce dependency between symbols across time. This behavior may be understood by the fact that the STTD processing may be implemented in binary or symbol domain (as opposed to the chip domain) as shown below.

FIG. **7** shows an STTD transmitter in accordance with another embodiment. In this embodiment, all channels except the DPCCH are STTD processed. Because the pilot signal is embedded in the DPCCH, this structure may offer the benefit of not requiring significant modification of the channel estimation at the Node-B receiver side. The STTD transmitter in FIG. **7** is substantially similar to the STTD transmitter in FIG. **6**. Therefore, it will not be explained in detail for simplicity.

FIG. **8** shows an STTD transmitter in accordance with another embodiment. In this embodiment, E-DPCCH, E-DPDCH(s), and HS-DPCCH are STTD encoded and DPDCH(s) and DPCCH are not STTD encoded. With this embodiment, the modification requirement at the Node-B receiver may be reduced. The STTD transmitter in FIG. **7** is substantially similar to the STTD transmitter in FIG. **6**. Therefore, it will not be explained in detail for simplicity.

The channels over which the STTD processing is not applied may be transmitted over at least one antenna. The non-STTD channel(s) may be transmitted over one of the antennas, as shown in FIG. **9**(A). Alternatively, the identical signals of the non-STTD channel(s) may be transmitted over the two (or all) antennas, as shown in FIG. **9**(B). Alternately, the non-STTD channel(s) may be transmitted over two (or all) antennas in a time division duplex fashion in accordance with a configured pattern, as shown in FIG. **9**(C). Alternatively, any types of space time processing or multiple-input multiple-output (MIMO) schemes may be used for transmission of the non-STTD channel(s), as illustrated in FIG. **9**(D).

Different from the downlink in a UMTS communication system, the physical channels in the uplink are formed as real-valued sequences and fed into either the I branch or the Q branch of the complex channel independently. Each of the physical channels is spread and weighted by its own channelization code and gain factor. As a result, the complex signal generated in such way may not have the properties of a true two dimension constellation. It may exhibit imbalance in phase and amplitude between its I-phase and Q-phase components. Before sending to the radio front end, a complex scrambler may be applied, and this helps to even out the imbalance existing in the transmitted signal.

Embodiments for STTD encoder are disclosed hereafter. The STTD encoder may be a binary STTD encoder or a complex STTD encoder.

The binary STTD encoder operates in binary domain before the physical layer processing, (i.e., prior to the modulation mapping). Assuming b_i, i=0, 1, 2, . . . , N where N is the number of bits per symbol, are the bits to be transmitted, the STTD encoder manipulates these bits to generate the inputs to create diversity for the two (or more) separated antenna paths. Each channel may form real-valued information sequence independently, and the physical channels that may be placed on the I and Q branches separately may be treated by a different STTD encoder. The STTD encoding may then be performed separately for each I and Q branch. FIGS. **10**(A) and **10**(B) show example binary STTD encoders for binary phase shift keying (BPSK) modulated data transmission. One of them may be used for an I-branch channel and the other may be used for a Q branch channel. Each branch may use a different binary STTD encoder. The input bit b_i may take three values 0,1, and discontinues transmission (DTX). $\bar{b}_i$ is defined as follows: if $b_i=0$ then $\bar{b}_i=1$, if $b_i=1$ then $\bar{b}_i=0$, otherwise $\bar{b}_i=b_i$.

The dual binary STTD encoder configuration may vary depending on the size of modulation mapping. FIGS. **11**(A) and **11**(B) show example STTD encoders with example constellation mapping rules for each branch for 4-level pulse amplitude modulation (4PAM) modulation. One of them may be used for an I-branch channel and the other may be used for a Q-branch channel.

The dual binary STTD encoder may be extended to other constellations of any order. For example, constellation mapping rules for the STTD encoding in general may be as follows: (1) the data bits are taken for two consecutive symbols: $b_0 b_1 \ldots b_{N-1} b_N \ldots b_{2N-1}$, where N is the number of bits in a symbol, (2) the binary data for antenna 1 remains unchanged, (3) the order of two symbols is changed as follows to generate the data for antenna 2: $b_0 b_1 \ldots b_{N-1} b_N \ldots b_{2N-1} \rightarrow b_N \ldots b_{2N-1} b_0 b_1 \ldots b_{N-1}$, and (4) a constellation mapping rule is applied for the I-branch channels, whereby the first bit of the second symbol is inverted: $b_N \rightarrow \bar{b}_N$, and for the Q-branch channels, whereby the first bit of the first symbol is inverted: $b_0 \rightarrow \bar{b}_0$ (alternatively, different bit position may be inverted depending on the constellation mapping rule).

FIGS. **12**(A) and **12**(B) show example STTD encoders with constellation mapping rules for 8PAM. One of them may be used for an I-branch channel and the other may be used for a Q-branch channel.

FIG. **13** shows an example transmitter **1300** with a dual binary STTD encoder. The transmitter **1300** includes STTD encoders **1302**, modulation mappers **1304**, spreading blocks **1306**, gain control blocks **1308**, channel combining blocks **1310**, I/Q combining blocks **1312**, and scrambling blocks **1314**. Each channel may be processed individually by the STTD encoder **1302**. Each STTD processing block **1302** outputs two or more signal streams depending on the number of transmit antennas. Each signal stream from the STTD encoder **1302** is then processed by a modulation mapper **1304**, and then by a spreading block **1306**, and a gain control block **1308** with its own channelization code and gain factor. The channel combining block **1310** and the I/Q combining block **1312** merge all the channels into a complex signal, which is scrambled by a scrambling block **1314** before transmitted over the assigned antenna. Since it is implemented in the binary domain, the dual binary STTD encoder **1302** offers a simple solution that allows an implementation to duplicate two transmit chains, one for each antenna, without having to make much modification as compared to the conventional WTRU transmitter structure.

Since the symbol boundaries of all considered physical channels, (i.e., DPCCH, DPDCH, E-DPCCH, E-DPDCH, and HS-DPCCH), are aligned at certain time point, the STTD encoding may be performed in a complex domain. Due to the fact that each channel is spread in real domain and the complex signal comprises multiple channels, the STTD encoder should deal with different symbol durations resulted from different spreading factors (SFs) among the channels as shown in the Table 1.

TABLE 1

Physical channel type	SF	Symbols/slot
DPCCH	256	10
DPDCH	2, 4, 8, . . . , 256	10, . . . , 1280
HS-DPCCH	256	10
E-DPCCH	256	10
E-DPDCH	2, 4, 8, . . . , 256	10, . . . , 1280

FIG. **14** shows an example STTD transmitter **1400** with a complex STTD encoder. The transmitter **1400** comprises modulation mappers **1402***a*, **1402***b*, spreading blocks **1404***a*, **1404***b*, gain control blocks **1406***a*, **1406***b*, channel and I/Q combining blocks **1408***a*, **1408***b*, a complex STTD encoder **1410**, channel combining blocks **1412**, and scrambling blocks **1414**. STTD channels are processed by a modulation mapper **1402***a*, a spreading block **1404***a*, and a gain control block **1406***a*, and combined into a complex signal by the channel and I/Q combining block **1408***a*. The combined STTD channel signals are then processed by the complex STTD encoder **1410**. Non-STTD channels are processed by a modulation mapper **1402***b*, a spreading block **1404***b*, and a gain control block **1406***b*, and combined into a complex signal by the channel and I/Q combining block **1408***b*. The STTD-encoded STTD channel signals and the processed non-STTD channel signals are then combined by the channel combiners **1412**, and then processed by the respective scrambling blocks **1414** for transmission.

FIG. **15** shows an example complex STTD encoding process. It should be noted that the complex STTD encoding may be performed with any STTD transmitters disclosed above. The uplink channels (DPCCH, DPDCH(s), HS-DPCCH, E-DPCCH, E-DPDCH(s)) are spread by a specific spreading block **1502** with a specific channelization code with a specific spreading factor and combined to a complex signal by a combiner **1504**. The spreading factors for the uplink channels may be different. The combined complex signal **1505**, (i.e., a block of chips combined over multiple uplink channels, which will be referred to as "STTD symbol"), is scrambled by the scrambler **1506** and stored in buffers **1508***a*, **1508***b* in time alternation, (i.e., the switch **1507** switches every T time instant), so that two consecutive STTD symbols are processed by the STTD encoder **1510** for STTD encoding.

The switch **1507** is synchronized to a symbol boundary as follows. Over the complex signal, the STTD symbols are defined such that a symbol duration "T" equals to the length of data symbols from the channel with a largest spreading factor of value SF_{max}, and the time boundary is aligned with the data symbols from the channel with the largest spreading factor of value SF_{max}. Therefore, each STTD symbol comprises SF_{max} chips. The complex STTD operation is then performed over the STTD symbols S0 and S1 as follows:

$$[s_0 \;\; s_1] \Rightarrow \begin{bmatrix} s_0 & s_1 \\ -s_1^* & s_0^* \end{bmatrix}; \qquad \text{Equation (1)}$$

where * represents a complex conjugate. The complex conjugate and negative operations are performed over the whole waveform of the STTD symbols, or equivalently, over every chip of the spread complex signal. The matrix notation means that S_0 is transmitted first in its entirety and then followed by S_1 in its entirety at the first antenna, and $-S_1{}^*$ is transmitted first in its entirety and then followed by $S_0{}^*$ in its entirety at the second antenna. The receiver needs be aware of the symbol configuration and boundary to perform decoding.

FIG. **16** shows an example STTD symbol configuration for channels with different SF_S, where each of the STTD symbols (S_0 or S_1) contains S_{SFmax} chips. The channels may take any combination of SFs in any order. Channel 1 is spread with the largest SF (SF_{max}), and the STTD symbol of that channel contains one symbol of S_{SFmax} chips. Channel 2 is spread with a half of the SF_{max}, (i.e., $SF_{max}/2$), and the STTD symbols of that channel contains two symbols, each comprising $S_{SFmax}/2$ chips. Channel N is spread with SF_{max}/k, and the STTD symbols of that channel contains k symbols, each comprising S_{SFmax}/k chips. More than one channel may be spread with the same spreading factor and some spreading factors may not be used. For the channels that have spreading factor equal to SF_{max}, one information symbol is transmitted in an STTD symbol. The other channels may have more than one information symbols included in an STTD symbol, depending on the spreading factor. As shown in FIG. **16**, the number of data symbols contained in an STTD symbol for a particular channel is determined by the ratio of SF_{max} and SF associated to that channel. For example, if a channel is spread with a spreading factor $SF_{max}/2$, then the channel may have two data symbols per STTD symbol.

An exemplary complex STTD encoding applied to the high speed uplink packet access (HSUPA) data channels, (i.e., the E-DPDCHs), is illustrated hereafter with reference to FIG. **17**. FIG. **17** shows an example transmitter **1700** with a complex STTD encoder for transmission of four E-DPDCHs. The transmitter **1700** comprises modulation mappers **1702**, channelization blocks **1704**, gain control blocks **1706**, channel combiners **1708**, an I/Q combiner **1710**, and an STTD encoder **1712**. In this example, the WTRU transmits at a peak uplink data rate, where four E-DPDCHs are configured for uplink data transmission allowing a total of 11.5 Mbps of data throughput. The channelization codes and spreading factors used for these E-DPDCHs are specified in Table 2.

TABLE 2

E-DPDCH channels	Channelization codes	Spreading factor	I/Q path
E-DPDCH1	$C_{2,1}$	2	I
E-DPDCH2	$C_{2,1}$	2	Q
E-DPDCH3	$C_{4,1}$	4	I
E-DPDCH4	$C_{4,1}$	4	Q

In this example, E-DPDCHs 1 and 3 are mapped to I branch, and E-DPDCHs 2 and 4 are mapped to Q branch. The binary streams on each E-DPDCH are mapped to 4PAM symbols individually by the modulation mapper **1702**. Each of the E-DPDCHs is spread with a corresponding channelization code by the channelization block **1704** and then scaled with a corresponding gain factor by the gain control block **1706**. The E-DPDCHs may take different spreading factors, (i.e., 2 and 4 in this example). The outputs of the processing for each of the E-DPDCHs are the chips denoted by $x_1(n)$, $x_2(n)$, $x_3(n)$, $x_4(n)$, where n is the chip index.

E-DPDCHs 1 and 3 and E-DPDCHs 2 and 4 are then combined by the channel combining blocks **1708**, respectively, and then combined to a complex signal by the I/Q combining block **1710**. Combining the channels according to the I/Q path assignment listed in Table 2 yields:

$$x(n)=x_1(n)+jx_2(n)+x_3(n)+jx_4(n). \quad \text{Equation (2)}$$

After the complex STTD encoding by the STTD encoder **1712**, the first STTD symbol (even symbol) contains the following four chips:

$$s_0=\{x(0),x(1),x(2),x(3)\}; \quad \text{Equation (3)}$$

and the second STTD symbol (odd symbol) contains the following four chips:

$$s_1=\{x(4),x(5),x(6),x(7)\}. \quad \text{Equation (4)}$$

At antenna 1, S_0 is transmitted first and followed by S_1, and at antenna 2, $-S_1*$ is transmitted first and then followed by S_0*. The same procedure is repeated for the even and odd STTD symbols.

The complex STTD encoding above may be extended to a longer symbol period. The STTD symbol may contain more than one data symbol corresponding to the largest SF, which may allow longer diversity coherence time to combat slow fading channels. The value "T" in FIG. **15**, for example, may take an integer multiple of SF_{max} chips. FIG. **18** shows a block STTD encoder in accordance with one embodiment. FIG. **18** shows that the STTD symbol comprises more than one data symbol of S_{SFmax} chips. More than one channel may be mapped to the same spreading factor. The complex STTD encoder may offer better time diversity and the cubic metric of second antenna may be less affected. This embodiment may be extended to the dual binary STTD encoder described above with more bits in one symbol.

Embodiments for multi-antenna transmission schemes with pre-coding in the uplink are disclosed hereafter.

In HSUPA, UL physical layer comprises multiple dedicated physical channels, including control channels, such as DPCCH, E-DPCCH and HS-DPCCH, and data channels, such as DPDCH and E-DPDCH. When a WTRU is configured in a UL MIMO mode, the WTRU performs E-DCH transport format combination (E-TFC) selection to schedule one or more transport blocks in every TTI. When only one transport block is scheduled, it may be mapped to the primary transport block.

Hereinafter, the following terminologies will be used. E-DPDCH1 and E-DPDCH2 are two sets of E-DPDCHs mapped to the primary and secondary E-DCH data stream, which may also be referred to as primary and secondary stream. E-DPDCH1 and E-DPDCH2 may comprise one or more E-DPDCHs. E-DPDCH1_k denotes the k^{th} physical E-DPDCH of the primary E-DCH data stream, and E-DPDCH2_k denotes the k^{th} physical E-DPDCH of the secondary E-DCH data stream. DPDCH1 and DPDCH2 are two set of DPDCHs mapped to the primary and secondary DPDCH data stream, respectively. DPDCH1_n denotes the n^{th} physical DPDCH of the primary DPDCH data stream, where $n=0, \ldots, N_{max\text{-}dpdch1}$. DPDCH$2_n$ denotes the n^{th} physical DPDCH of the secondary DPDCH data stream, where $n=0, \ldots, N_{max\text{-}dpdch2}$. It should be noted that the embodiments disclosed herein are mainly described with reference to dual-E-DCH stream transmission, (i.e., both the primary E-DCH data stream and the secondary E-DCH data stream), but the embodiments are equally applicable to a single E-DCH stream transmission.

The transmitter embodiments disclosed below show pre-coding for the dual-stream transmission, (i.e., two transport blocks: primary and secondary transport blocks). It should be noted that all the transmitter embodiments disclosed below may operate with a single stream or multiple streams. If a single stream needs to be transmitted, one transmit chain in the transmitter is utilized for transmission of the single stream. If dual stream is configured, primary and secondary E-DCH transport blocks pass through the transport channel (TrCH) processing for E-DCH which may include adding cyclic redundancy check (CRC) parity bits to the transport block, code block segmentation, channel coding, physical layer hybrid automatic repeat request (HARQ), rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2, and the like. When only one transport block is scheduled, it may be mapped to the primary transport block, using one signal chain.

FIG. **19** shows an example transmitter **1900** in accordance with one embodiment. In this embodiment, the transmitter **1900** applies pre-coding operation to both E-DPCCH and E-DPDCH after spreading operations. By applying the same precoding weights to both the E-DPDCH and the E-DPCCH of the same stream, both the E-DPDCH and the E-DPCCH may experience similar propagation conditions. As a result, the conventional power setting rules for the E-DPCCH and the E-DPDCH may be re-used.

The transmitter **1900** comprises physical layer processing blocks **1902** for E-DPDCH, spreading blocks **1904**, **1906**, **1914**, combining blocks **1908**, **1916**, a precoder **1910**, a weights selection block **1912**, scramblers **1918**, filters **1920**, and antennas **1922**. Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **1902** for E-DPDCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured). Either E-DPDCH1 or E-DPDCH2 may comprise one or more E-DPDCHs depending on the E-TFCI selected for the primary and secondary E-DCH transport blocks, which may or may not be the same.

After the physical layer processing, the data streams on the E-DPDCH1 and the E-DPDCH2 are spread by the spreading blocks **1904**, respectively. Spreading operations on the E-DPCCH1 and the E-DPCCH2 are also performed by the spreading blocks **1906**. The E-DPCCH2 is present if there are two E-DCH transport blocks being transmitted. In case where a single E-DCH stream is transmitted, the E-DPCCH2 may not be transmitted. After the spreading operation, the real-valued chips on the I and Q branches of the E-DPDCH(s) and the E-DPCCH(s) are summed by the combiners **1908** into two complex-valued streams. The two complex-valued streams are then processed by the pre-coder **1910**. The pre-coder **1910** applies pre-coding weights determined by the weights selection block **1912** to distribute the signals to the antennas **1922**. Depending on the number of transport blocks scheduled for transmission, the weights selection block **1912** may provide one or more sets of pre-coder weights. The pre-coding operation will be explained in detail below.

For every pre-defined or configured period, (e.g., every TTI or slot), the pre-coder weights may be updated for the upcoming transmission. Based on the channel-dependent feedback information from the Node-B, the weights selection block **1912** may select the pre-coding weights, which will be explained in detail below.

After the precoding, and spreading on all other configured physical channels by spreading blocks **1914**, the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **1916** into two complex-valued streams, which are then scrambled by the scramblers **1918** with one or two complex-valued scrambling codes. The WTRU then transmits data on both antennas after filtering. The WTRU may signal the pre-coding weights on the UL, which will be explained in detail below.

FIG. **19** shows that the precoding is performed after the spreading and combining of the E-DPDCH(s) and E-DPCCH(s). However, the pre-coding operation may be performed at any stage, either at the symbol or chip level, and may be applied to one or more data or control channels before or after spreading or scrambling operations depending on the pre-coder's location in the transmitter.

FIG. **20** shows an example transmitter **2000** in accordance with another embodiment. In this embodiment, the pre-coding is applied to the E-DPDCHs after spreading operation. The transmitter comprises physical layer processing blocks **2002** for E-DPDCH, spreading blocks **2004**, **2010**, **2014**, combining blocks **2012**, **2016**, a precoder **2006**, a weights selection block **2008**, scramblers **2018**, filters **2020**, and antennas **2022**. Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **2002** for E-DCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured).

After the physical layer processing, the data streams on the E-DPDCH1 and E-DPDCH2 are spread by the spreading blocks **2004**. After the spreading operation, the chip streams are processed by the precoder **2006**. The pre-coder **2006** applies pre-coding weights determined by the weights selection block **2008** to distribute the signals to the antennas **2022**. Depending on the number of transport blocks scheduled for transmission, the weights selection block **2008** may provide one or more sets of pre-coder weights.

Spreading operation on the E-DPCCH1 and the E-DPCCH2, and all other physical channels is performed by the spreading blocks **2010**, **2014**, respectively. After the spreading operation on the E-DPCCH(s) and all other configured physical channels, the chips on the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **2012**, **2016** into two complex-valued streams, which are then scrambled by the scramblers **2018** with one or two complex-valued scrambling codes. The WTRU then transmits data on both antennas after filtering.

In accordance with this embodiment, since control channels are not pre-coded, the conventional receiver may be used to receive the control channels without a need to inverse the spatial pre-coding operation for the control information. Further, since the E-DPCCH is not pre-coded, it may be decoded using a different receiver than the one for the E-DPDCH, which may expedite decoding of the transport block size, happy bit, and retransmission sequence number (RSN) information, thus reducing the decoding latency.

In addition, the E-DPCCH reliability may be linked to the DPCCH, which is power-controlled and experiences the same channel conditions. In that way the reliability of the control channel becomes independent of the pre-coding. Further, compared with data channels, much stronger protection may be given to the control channels so that they may be demodulated and decoded correctly with much higher probability. The control channels may not be pre-coded since spatial multiplexing of two control channels would generate inter-stream interferences and consequently may cause performance degradation. Instead, to provide additional transmit diversity gain and improve reception reliability to the control channels, an open loop transmit diversity scheme such as space time block coding (STBC) may be implemented.

In addition, since E-DPCCH1 and E-DPCCH2 are sent over the two different antennas without pre-coding, both E-DPCCHs may be used as additional pilot information (in decision directed mode) for improved channel estimation.

FIG. **21** shows an example transmitter **2100** in accordance with another embodiment. In this embodiment, the pre-coding operation is applied to not only the E-DPCCH and the E-DPDCH but also to the HS-DPCCH after spreading operations. The transmitter **2100** comprises physical layer processing blocks **2002** for E-DPDCH, spreading blocks **2104**, **2106**, **2108**, **2118**, combining blocks **2110**, **2112**, **2120**, a precoder **2114**, a weights selection block **2116**, scramblers **2122**, filters **2124**, and antennas **2126**.

Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **2102** for E-DCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured). Either E-DPDCH1 or E-DPDCH2 may comprise one or more E-DPDCHs depending on the E-TFCI selected for the transport block, which may or may not be the same, (i.e., the primary transport block may be mapped to one or more E-DPDCHs in E-DPDCH1 and the secondary transport block may be mapped to one or more E-DPDCHs in E-DPDCH2).

After the physical layer processing, the spreading blocks **2104** perform spreading operation on the E-DPDCH1 and E-DPDCH2. Spreading operation on the E-DPCCH1 and E-DPCCH2, after physical layer processing, is performed by the spreading blocks **2106**. Spreading operation on the HS-DPCCH, after physical layer processing, is also performed by the spreading block **2108**. After the spreading operation, the real-valued chips on the I and Q branches of the E-DPDCH(s), the E-DPCCH(s), and the HS-DPCCH are summed by the combiners **2110**, **2112** into two complex-valued streams. The two complex-valued streams are then processed by the pre-coder **2114**. The pre-coder **2114** applies pre-coding weights determined by the weights selection block **2116** to distribute the signals to the antennas **2126**.

DPCCH(s) and DPDCH(s) are spread by the spreading blocks **2118**. The real-valued chips on the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **2120** into two complex-valued streams, which are then scrambled by the scramblers **2122** with one or two complex-valued scrambling codes. The WTRU then transmits data on both antennas after filtering. The WTRU may signal the pre-coding weights on the UL, which will be explained in detail below.

FIG. **21** shows that the precoding is performed after the spreading and combining of the E-DPDCH, E-DPCCH, and HS-DPCCH. However, the pre-coding operation may be performed at any stage, at either symbol or chip level, and may be applied to one or more data or control channels before or after spreading or scrambling operations depending on the pre-coder's location in the transmitter.

This embodiment allows the control channels (including the HS-DPCCH) to take advantage of the additional coverage that pre-coding may provide including the single-stream case.

The precoding weights applied to the E-DPCCH and the HS-DPCCH in case of a single E-DPDCH stream being transmitted may be different from those when two E-DPDCH streams are being transmitted, since weight generation for diversity may be different from the one for spatial-multiplexing. When there is one E-DPDCH stream, it may share the same precoding weights as E-DPCCH and HS-DPCCH.

FIG. **22** shows an example transmitter **2200** in accordance with another embodiment. In this embodiment, the pre-coding is applied to the E-DPDCH(s) before spreading operations, (i.e., at the symbol level). The processing power for pre-coding operation may be saved as it is less computationally intensive to apply the weights at the symbol level rather than at the chip level.

The transmitter **2200** comprises physical layer processing blocks **2202** for E-DPDCH, a precoder **2204**, a weights selection block **2206**, spreading blocks **2208**, **2210**, **2214**, combining blocks **2212**, **2216**, scramblers **2218**, filters **2220**, and antennas **2222**. Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **2202** for E-DCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured).

After the physical layer processing, the data streams, on the E-DPDCH1 and E-DPDCH2 are processed by the precoder **2204** at symbol level, (i.e., before spreading). The pre-coder **2204** applies pre-coding weights determined by the weights selection block **2206** to distribute the signals to the antennas **2222**. Depending on the number of transport blocks scheduled for transmission, the weights selection block **2206** may provide one or more sets of pre-coder weights.

After the precoding, the data streams are spread by the spreading blocks **2208**. Spreading operation on the E-DPCCH1 and the E-DPCCH2, and all other physical channels is performed by the spreading blocks **2210**, **2214**, respectively. After the spreading operation on the E-DPDCH(s), E-DPCCH(s) and all other configured physical channels, the chips on the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **2212**, **2216** into two complex-valued streams, which are then scrambled by the scramblers **2218** with one or two complex-valued scrambling codes. The WTRU then transmits data on both antennas **2222** after filtering.

FIG. **23** shows an example transmitter **2300** in accordance with another embodiment. In accordance with this embodiment, the pre-coding operation is applied to all channels including both control and data channels after scrambling operations. The transmitter **2300** comprises physical layer processing blocks **2302** for E-DPDCH, spreading blocks **2304**, **2306**, **2308**, combining blocks **2310**, **2312**, scramblers **2314**, a precoder **2316**, a weights selection block **2318**, filters **2320**, and antennas **2322**. Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **2302** for E-DCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured).

After the physical layer processing, the data streams on the E-DPDCH1 and E-DPDCH2 are spread by the spreading blocks **2304**. Spreading operation on the E-DPCCH1 and the E-DPCCH2, and all other physical channels is performed by the spreading blocks **2306**, **2308**, respectively. After the spreading operation on the E-DPDCH(s), E-DPCCH(s) and all other configured physical channels, the chips on the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **2310**, **2312** into two complex-valued streams, which are then scrambled by the scramblers **2314** with one or two complex-valued scrambling codes.

After the scrambling operation, the pre-coding operation is performed by the precoder **2316** on the combined data stream of all channels. The pre-coder **2316** applies pre-coding weights determined by the weights selection block **2318** to distribute the signals to the antennas **2322**. Depending on the number of transport blocks scheduled for transmission, the weights selection block **2318** may provide one or more sets of pre-coder weights. The transmitter **2300** then transmits data on both antennas after filtering.

Two different scrambling codes may be used for the two antennas. Alternatively, a single scrambling code may be used for the antennas. If two different scrambling codes are configured by the network, the same orthogonal variable spreading factor (OVSF) codes, (i.e., the channelization codes), used on the DPCCH, DPDCH and E-DPCCH for the primary stream may be reused for those for the secondary stream if the dual-stream is configured with different modulation and coding scheme (MCS). Furthermore, if a dual-stream is configured, the OVSF codes used for the primary stream may be reused for the secondary stream under certain conditions including, but not limited to: if both streams use the same transport format, if both stream use the same MCS, and/or if both stream use the same E-TFCI. Otherwise, the WTRU may use a different set of channelization code(s) for the second stream. The channelization code(s) for the second set of E-DPDCHs may be taken from a different OVSF branch altogether, selected in such a way to minimize inter-stream interference and/or cubic metric impacts.

With two different scrambling codes, from the network or the Node-B perspective, the two streams may be interpreted as if they were coming from two different WTRUs. From an implementation perspective, this may allow minimal changes in the Node-Bs receiver architecture (as small as a software upgrade) and at the system level may not impact the resources allocation and cell planning so much as the uplink is not typically limited by the number of scrambling codes but rather from the interference. With the special case of a diagonal precoder,

$$\left(\text{e.g., } \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\right),$$

this transmitter structure from the physical layer perspective becomes almost equivalent to having two separate WTRUs. This may be advantageous from both the Node-B and the WTRU implementation perspective as it would simplify implementation significantly.

FIG. **24** shows an example transmitter **2400** in accordance with another embodiment. In accordance with this embodiment, the pre-coding operation is applied to all channels including both control and data channels before scrambling operations. Optionally, pre-coding operation may be done before scrambling operations, which is mathematically equal when using the same scrambling. The transmitter **2400** comprises physical layer processing blocks **2402** for E-DPDCH, spreading blocks **2404**, **2406**, **2408**, combining blocks **2410**, **2412**, a precoder **2414**, a weights selection block **2416**, scramblers **2418**, filters **2420**, and antennas **2422**. Primary and secondary E-DCH transport blocks, if dual-stream is configured, (or a primary E-DCH transport block if one stream is configured), are processed by the physical layer processing blocks **2402** for E-DCH. The physical layer processing may include adding CRC parity bits to the transport block, code block segmentation, channel coding, physical layer HARQ, rate matching, physical channel segmentation, interleaving and mapping to E-DPDCH1 and E-DPDCH2 if dual-stream is configured, respectively, (or to E-DPDCH1 if a single stream is configured).

After the physical layer processing, the data streams on the E-DPDCH1 and E-DPDCH2 are spread by the spreading blocks **2404**. Spreading operation on the E-DPCCH1 and/or the E-DPCCH2, and all other physical channels is performed by the spreading blocks **2406**, **2408**, respectively. After the spreading operation on the E-DPDCH(s), E-DPCCH(s) and all other configured physical channels, the chips on the I and Q branches of all the configured physical channels, (e.g., DPCCH, DPDCH, HS-DPCCH, E-DPCCH, and E-DPDCH), are summed by the combiners **2410**, **2412** into two complex-valued streams.

A pre-coding operation is then performed by the precoder **2414** on the combined two complex data streams of all channels. The pre-coder **2414** applies pre-coding weights determined by the weights selection block **2416** to distribute the signals to the antennas **2422**. Depending on the number of transport blocks scheduled for transmission, the weights selection block **2416** may provide one or more sets of precoder weights. After the precoding, the data streams are scrambled by the scramblers **2418** with one or two complex-valued scrambling codes. The transmitter **2400** then transmits data on both antennas **2422** after filtering.

When two different scrambling codes are used for both antennas, separation of each stream may be achieved via scrambling code in the transmitter of FIG. **23**, whereas per-antenna separation may be achieved via scrambling code in the transmitter of FIG. **24**. Having a means to separate the signals at the antenna may be advantageous for channel estimation when the DPCCH is pre-coded, as is the case in this embodiment.

In accordance with this embodiment, the Node-B receiver may separate signals based on antenna, and even if the pilot signals are pre-coded, the channel matrix may be estimated correctly so that the Node-B may determine which set of precoding weights to signal to the WTRU. In accordance with this embodiment, the effective space-time channel for each stream may be estimated with a single DPCCH for detection, and the channel matrix may be estimated by separating via scrambling codes. This structure also has an advantage that for single stream transmission, minimum or no change on the receiver side is needed. This may have significant advantage for reducing implementation cost for certain technologies which are widely deployed such as UTRA.

FIG. **25** shows an example transmitter **2500** in accordance with another embodiment. The transmitter **2500** is similar to the transmitter **2100** of FIG. **21**. A difference is that precoding is also applied to DPDCH, if configured, after spreading operations. This allows the DPDCHs to benefit from pre-coding and the closed loop transmit gain that may result. In other words, transmitter **2500** applies pre-coding to all configured channels except DPCCH1 and DPCCH2.

Transmitted signal structure and spreading operations are explained hereafter. For any transmitter embodiments described above, the transmitted signal, (i.e., the possible dedicated physical channels which may be configured simultaneously for a WTRU), may comprise one or more of, in any combination: DPCCH1, DPCCH2, DPDCH1, DPDCH2, HS-DPCCH, E-DPDCH1, E-DPDCH2, E-DPCCH1, and/or E-DPCCH2.

DPCCH1 and DPCCH2 are transmitted using OVSF code Cc1 and Cc2, respectively, to support channel estimation at the Node-B by using pilot signal and carry the control information. If pilot signal (at the symbol level) in DPCCH1 and DPCCH2 are orthogonal, the OVSF code Cc1 and Cc2 may be the same. If the same pilot signal is used in both DPCCH1 and DPCCH2, the OVSF code Cc1 and Cc2 should be orthogonal. Both DPCCH1 and DPCCH2 may be transmitted in pair unless during the period where the UL transmission is not allowed, for example, when the WTRU is in DTX or compressed mode.

The control information carried on the DPCCH1 may include transport format combination index (TFCI), feedback information (FBI) and transmit power control (TPC). The DPCCH2 may carry a pilot signal. Alternatively, the DPCCH2 may carry another set of control information besides the pilot signal, which may include part or all of the control information carried on the DPCCH1, and/or other new control information, such as pre-coding weight, etc.

Depending on the number of DPDCH data streams being transmitted, one or two set of DPDCH(s) may be transmitted on two antennas. Two sets of DPDCH, (i.e. DPDCH1 and DPDCH2), may be respectively transmitted by using OVSF code set Cd1 and Cd2. Either DPDCH1 or DPDCH2 may comprise zero, one or more DPDCHs which may or may not be the same. The actual number of configured DPDCHs in DPDCH1 and DPDCH2, (denoted $N_{max\text{-}dpdch1}$ and $N_{max\text{-}dpdch2}$), may be respectively equal to the largest number of DPDCHs from all the transport format combinations (TFCs) in the transport format combination set (TFCS). Alternatively, neither DPDCH1 nor DPDCH2 may be transmitted when no DPDCH data stream is configured. Alternatively, DPDCH1 may be transmitted using OVSF code set

Cd1 when a single DCH data stream is configured. To maintain the backward compatibility to 3GPP Release 9, when an E-DCH is configured, either $N_{max\text{-}dpdch1}$ or $N_{max\text{-}dpdch2}$ may be 0 or 1, or $N_{max\text{-}dpdch1}$ may be 0 or 1 while $N_{max\text{-}dpdch2}$ is 0.

The HS-DPCCH may be transmitted using OVSF code Chs to carry HARQ ACK/NACK, channel quality indicator (CQI) and precoding indicator (PCI) if the WTRU is in a downlink (DL) MIMO mode.

The E-DPCCH1 and E-DPCCH2 may be respectively transmitted using OVSF code Cec1 and Cec2 to provide the control information to the associated the E-DCH. For a single stream case, the E-DPCCH1 may be transmitted. Alternatively, a single E-DPCCH may be used to carry the information for both streams, in which case Cec1 may be used.

A new E-DPCCH frame/slot format and/or coding scheme may be used to carry all the necessary information. In accordance with one embodiment, a new slot format allowing more information symbols to be carried in a single TTI is used. For example, the new slot format may use a smaller spreading factor, (e.g., 128 instead of 256), to allow twice the number of information symbols to be carried in one TTI of the E-DPCCH. In that case, the conventional coding scheme for the E-DPCCH may be re-used for each stream independently.

In accordance with another embodiment, time-division multiplexing may be used to transmit the two E-DPCCHs. For instance, E-DPCCH1 and E-DPCCH2 may be carried in the first and second half of the TTI, respectively. Another field may be included in the E-DPCCH1 and/or E-DPCCH2 to indicate the number of streams transmitted in the current TTI. In case a single stream is being transmitted, the E-DPCCH1 may be repeated in the second half of the subframe. In such cases, when E-DPCCH power boosting is configured, the WTRU may calculate the required power boosting for each E-DPCCH and apply the largest one of the two for both E-DPCCHs that are time-multiplexed in the same E-DPCCH subframe.

In accordance with another embodiment, a new coding scheme may be used whereby the information for both E-DCH streams is jointly encoded in a single E-DPCCH. A new field may be introduced in the new E-DPCCH to indicate the number of streams carried in the TTI. This new E-DPCCH may carry, for example, a number of streams indicator bit, a single "Happy bit" value, one E-TFCI per stream and one retransmission sequence number (RSN) per stream for up to 20 bits of information. This new E-DPCCH may be carried using the conventional slot format with spreading factor of 256 or alternatively using a lower spreading factor. This new E-DPCCH may be encoded using an existing code or a new code, (e.g., a new (30, 20) code for the case where SF 256 is used, or a new (60,20) code in case SF of 128 is used). The WTRU may apply a larger power offset to the E-DPCCH when two streams are being transmitted to ensure reliable reception. When a single stream is transmitted, the fields carrying the E-TFCI and the RSN for the second stream may be DTXed.

Depending on the number of streams to be transmitted, one or two set, (i.e., multiple codes), of E-DPDCH may be transmitted. For dual-stream case where the WTRU performs the E-TFC selection, which results in two transport blocks to be transmitted and the WTRU applies the OVSF configuration corresponding to dual stream transmission and transmits the dual streams, the E-DPDCH1 and the E-DPDCH2 may be respectively transmitted using OVSF code set Ced1 and Ced2. Either E-DPDCH1 or E-DPDCH2 may comprise one or more E-DPDCHs depending on the E-TFCI selected for either primary or secondary E-DCH transport block, which may or may not be of the same size. In the dual stream case, each E-DCH transport block may have a different size or E-TFCI, so the channelization code set Ced1 and Ced2 may or may not be different. Alternatively, for a single stream case where one transport block of E-DCH is scheduled, the E-DPDCH1 may be transmitted by using OVSF code set Ced1 which may be, for example, the conventional OVSF code set used for single carrier HSUPA without MIMO configured.

If the spreading factor determination results in two different channelization codes Ced1 and Ced2 for the E-DPDCH1 and E-DPDCH2, respectively, to ensure the mathematical or functional equivalence between the case of precoding in symbol level before spreading and the case of precoding in chip level after spreading, Ced1, Ced2 may be chosen such that one of them may be the repetition of the other.

When the WTRU is configured in a closed-loop transmit diversity (CLTD) mode or a single stream MIMO mode, neither E-DPDCH2 nor E-DPCCH2 may be configured or transmitted. More specifically, when a single E-DCH stream is being transmitted, the second set of E-DCH data and control channels may not be transmitted by the WTRU.

The DPCCH2 may be mapped to I or Q branch. In order to select the best channelization code for the DPCCH2, first, the available channelization code space is searched for the DPCCH2 by not selecting the code used by other channels on either I or Q branches to reduce the phase error during channel estimation. Depending on whether a DCH is configured or not, the available channelization code space obtained in the first step may be different. Among the available code space, the best channelization code is selected to obtain a smaller cubic metric (CM) value than other codes given a transmitter structure and configuration. For example, when using the transmitter **2400** with a CLTD mode configuration, if the DPCCH2 is configured on an I branch, the channelization code of the DPCCH2 may be selected as $C_{ch,256,32}$, and if the DPCCH2 is configured on a Q branch, the channelization code of the DPCCH2 may be selected as $C_{ch,256,2}$.

The OVSF codes Cc1, Cc2, Cd1, Cd2, Chs, Cec1, Cec2, Ced1, and Ced2 may be fixed in the standards or configured by the network.

FIG. **26** shows the spreading operation, which includes spreading with a given channelization code, weighting, and IQ phase mapping. The spreading operation is applied to every physical channel. The spreading operation may be represented by:

$$SF\_CH=CH*C_{CH}*\beta_{CH}*iq_{CH}, \qquad \text{Equation (5)}$$

where, CH is the real-valued bits of the physical channel to be spread and weighted, C_{CH} is the OVSF channelization code fixed in the standards or configured by the network, β_{CH} is a gain factor that may be signaled or calculated based on the signaled parameters and the transport block size or number of information bits, iq_{CH} is a complex value for the I or Q branch mapping, where $iq_{CH}=1$ or $iq_{CH}=j$.

After spreading operation, the streams of real-valued chips on I and Q branches are summed into two complex-valued streams which are then scrambled by one or two complex-valued scrambling codes configured by the network. The operation is carried out as follows: the WTRU receives a configuration message carrying scrambling code information. The WTRU applies the scrambling code to the complex-valued streams. Scrambling may be carried out after the spreading operation for each channel separately, after the spread channels are all summed together, or after summing of all non-precoded and pre-coded channels as shown in different transmitter embodiments described above. Optionally, the WTRU may apply the pre-coding weights to two complex scrambled streams if transmitter **2300** is used. The WTRU then transmits data on both antennas after filtering with transmit pulse, (e.g., a root raised-cosine filter).

Pre-coding operations are explained hereafter. FIG. **27** shows an example pre-coder for the dual stream case. The precoding operation may be represented as follows:

$$\begin{bmatrix} B_p \\ B_s \end{bmatrix} = W\begin{bmatrix} A_p \\ A_s \end{bmatrix} = \begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix}\begin{bmatrix} A_p \\ A_s \end{bmatrix} = \begin{bmatrix} w_1A_p + w_3A_s \\ w_2A_p + w_4A_s \end{bmatrix}, \quad \text{where } W = \begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix} \qquad \text{Equation (6)}$$

is the pre-coding matrix. A_p and A_s may be complex or real values. After applying the pre-coding operation, A_p and A_s are distributed on the first and second transmit antenna, which are represented by $B_p=w_1A_p+w_3A_s$ and $B_s=w_2A_p+w_4A_s$, respectively.

When $A_s=0$, (i.e., a single stream case), $B_p=w_1A_p$ and $B_s=w_2A_p$ are respectively sent on the first and second antenna.

FIG. **28** shows another example pre-coder for the dual stream case. In HSUPA, real-valued I/Q branches are separated before I/Q multiplexing. The pre-coding operation is applied to the I and Q branches of each of the primary and secondary streams A_p and A_q, respectively, then I/Q multiplexing is performed on the pre-coded I/Q branch data. In accordance with this embodiment, the I/Q branches are processed in parallel, reducing the implementation complexity. Mathematically, the outputs of the two pre-coders are the same given the same input, which may be represented as follows:

$$\begin{bmatrix} B_p \\ B_s \end{bmatrix} = W\begin{bmatrix} A_p \\ A_s \end{bmatrix} = \begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix} \qquad \text{Equation (7)}$$

$$\begin{bmatrix} A_{p,I} + jA_{p,Q} \\ A_{s,I} + jA_{s,Q} \end{bmatrix} = \begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix}\left(\begin{bmatrix} A_{p,I} \\ A_{s,I} \end{bmatrix} + j\begin{bmatrix} A_{p,Q} \\ A_{s,Q} \end{bmatrix}\right) = \begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix}\begin{bmatrix} A_{p,I} \\ A_{s,I} \end{bmatrix} + j\begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix}\begin{bmatrix} A_{p,Q} \\ A_{s,Q} \end{bmatrix}$$

where $A_p=A_{p,I}+jA_{p,Q}$, $A_s=A_{s,I}+jA_{s,Q}$, and $A_{p,I}$ and $A_{s,I}$ are the real part (I branch) of the complex-valued A_p and A_s, $A_{p,Q}$ and $A_{s,Q}$ are the image part (Q branch) of the complex-valued A_p and A_s. The above two pre-coder embodiments may be used for one or more physical channels, and may be used in combination with any transmitter structures described herein.

In order to save on computing complexity, the pre-coding may be performed at the symbol level as opposed to the chip level. For these to be equivalent, the channelization codes (or spreading codes), gain factor and I/Q mapping need to be the same for both channels to pre-code, or the precoding weight matrix W is diagonal.

FIG. **29** shows another example pre-coder for the dual stream case. If the two streams use different spreading factors, for the pre-coding-before-spreading be equivalent to the spreading-before-pre-coding the spreading code of the highest data rate channel needs to be constructed from a repetition of the spreading code for the lowest data rate channel. For example, assuming two channels with spreading factors 2 and 4 are being transmitted. If the channelization code for the channel with a spreading factor 2 is $C_{ch2}=[1\ -1]$, the channelization code for the channel with a spreading factor 4 may be $C_{ch4}=[C_{ch2}\ C_{ch2}]=[1\ -1\ 1\ -1]$.

In FIG. **29**, the precoding is applied before spreading and two data streams C_s and C_p (assuming C_{ed1} and C_{ed2} are OVSF codes for data streams C_s and C_p, respectively) use OVSFs with different spreading factors SF_{ed1} and SF_{ed2} with $SF_{ed2}=N\times SF_{ed1}$. The data stream with the lowest (or lower) symbol rate (C_s) is weighted and repeated N times before mixed with the other stream (C_p) that is weighted. At the output of the precoder, both streams D_s and D_p are spread with the channelization code of the smallest spreading factor of SF_{ed1} and SF_{ed2} (C_{ed1} in this example).

The above embodiment may be applied for example to the E-DCH transmission with four E-DPDCHs. FIG. **30** shows an example transmitter for the two stream case. For applying pre-coding before spreading, the channels are grouped first with respect to their spreading factor, (i.e., channels of the same spreading factors are grouped together), and the data streams are pre-coded and then spread.

$\text{E-DPDCH}_k^{(l)}$ is defined as the k^{th} E-DPDCH for the l^{th} stream. Four E-DPDCHs are used for each of the two data streams. For each stream, the first and second E-DPDCHs are spread using the same channelization code of the same spreading factor, (e.g., **2**), and the first E-DPDCH is mapped on the I branch and the second E-DPDCH is mapped on the Q branch, and the third and fourth E-DPDCHs are spread using the same channelization code of the same spreading factor, (e.g., **4**), and the third E-DPDCH is mapped on the I branch and the fourth E-DPDCH is mapped on the Q branch. In FIG. **30**, the first and second E-DPDCHs of the first stream are combined by a combiner **3002** into a complex signal, and the first and second E-DPDCHs of the second stream are combined by a combiner **3004** into a complex signal and then pre-coded by a pre-coder **3010**, and the third and fourth E-DPDCHs of the first stream are combined by a combiner **3006** into a complex signal, and the third and fourth E-DPDCHs of the second stream are combined by a combiner **3008** into a complex signal and then pre-coded by a pre-coder **3012**. After the pre-coding, the first and second E-DPDCHs of the two streams are spread by channelization blocks **3014**, **3016** with a channelization code of the same spreading factor, (in this example, a channelization code of spreading factor 2 ($C_{ch,2,1}$)), and the third and fourth E-DPDCHs of the two streams are spread by channelization blocks **3018**, **3020** with a channelization of the same spreading factor, (in this example, a channelization code of spreading factor 4 ($C_{ch,4,1}$)). After spreading, the antenna components are combined by the combiners **3022**, **3024** for transmission.

Other combination of pairs of E-DCHs may also be implemented. Up to two E-DPDCHs from the same stream mapped on different I/Q branches may be combined together for pre-coding. The inputs to the pre-coder may comprise two complex signals from each stream. If the spreading factor for all inputs to the pre-coder is the same, the channelization codes for input channels to the same pre-coder may be the same. If all inputs to the pre-coder do not have the same data rate or spreading factor, the lower data rate input(s) may be repeated for matching the highest data rate input.

A combination of the approaches illustrated in FIG. **28** and FIG. **29** may be used to optimize the computational complexity of applying the precoding operation.

It is further noted that the embodiments illustrated in FIGS. **28-30** may also be used to other pair of channels besides the E-DPDCH when the spreading code properties permits.

Embodiments for generating pre-coding weights are described. The pre-coding weights matrix W may be chosen from a set of pre-coder matrices, (i.e., codebook), or be determined without a codebook.

If codebook-based pre-coding is used, unitary matrices may be used as the pre-defined pre-coder matrix. One example codebook is as follows:

$$W \in \left\{ \begin{array}{c} \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ j & -j \end{bmatrix}, \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1+j}{2} & \frac{-1-j}{2} \end{bmatrix}, \\ \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1-j}{2} & \frac{-1+j}{2} \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \end{array} \right\}.$$

DL MIMO pre-coding matrix may be reused for the UL MIMO, whose weights w_1, w_2, w_3 and w_4 of the 2×2 pre-coding matrix are defined as follows:

$$w_3 = w_1 = 1/\sqrt{2} \quad \text{Equation (8)}$$

$$w_4 = -w_2, \quad \text{Equation (9)}$$

$$w_2 \in \left\{\frac{1+j}{2}, \frac{1-j}{2}, \frac{-1+j}{2}, \frac{-1-j}{2}\right\}. \quad \text{Equation (10)}$$

If a single transport block is scheduled in one TTI, the pre-coding vector (w_1, w_2) may be used for transmission. If two transport blocks are scheduled in one TTI, two orthogonal pre-coding vectors may be used to transmit the two transport blocks. The pre-coding vector (w_1, w_2) may be called the primary pre-coding vector which is used for transmitting the primary transport block and the pre-coding vector (w_3, w_4) may be called the secondary pre-coding vector which is used for transmitting the secondary transport block, respectively.

If non-codebook-based pre-coding is used, the pre-coding may be based on transmit beamforming (TxBF), for example, eigen-beamforming based on singular value decomposition (SVD). For pre-coding using eigen-beamforming, the channel matrix H is decomposed using an SVD, (i.e., a pre-coding matrix W is a unitary matrix chosen such that $H=U\Sigma W^H$. The eigen-channel's signal-to-noise ratio (SNR) may be matched by selecting a suitable modulation and coding scheme (MCS) for each stream.

Generally, non-codebook-based pre-coding schemes give the better performance and more freedom to the size of the codebook than codebook-based pre-coding at the cost of feedback signaling overhead in the DL and potential control signaling overhead in the UL.

The special case of the identity matrix

$$\left(\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\right)$$

as a pre-coding codebook is equivalent for certain transmitter structures in single stream operations to a switch antennas transmitter (thereby using switch antenna transmit diversity (SATD)). For example, this is the case for transmitter **2100** and **2500** and also **2300** and **2400** when the same scrambling code is used.

Embodiments for selecting and signaling the pre-coding weights are explained hereafter.

When channel-dependent MIMO schemes are used for HSUPA, channel-dependent information may be sent from a Node-B to a WTRU for pre-coding operation. This information allows the WTRU to adjust the pre-coding weights as a function of the channel propagation conditions. For example, this channel-dependent feedback information may comprise uplink pre-coding control indication (UPCI), channel state information (CSI), or CSI-related information (such as serving grants carried on an E-DCH absolute grant channel (E-AGCH), an E-DCH relative grant channel (E-RGCH) or TPC commands carried on DL DPCCH/F-DPCCH, etc.).

A Node-B may determine a set of pre-coding weights, and indicate it to the WTRU. For example, the set of pre-coding weights may be indicated to the WTRU via a control signal carrying uplink pre-coding control information (UPCI).

The UPCI may be transmitted by the Node-B using an E-DCH HARQ indicator channel (E-HICH) and an E-RGCH. The E-HICH and E-RGCH are both currently using a similar structure. Forty (40) signatures are defined with forty sequences which comprise a pre-defined signature hopping pattern over 3 radio slots. For normal operations, the network assigns one sequence per E-HICH or E-RGCH which are modulated by values +1, −1 or 0 (DTX) by the Node-B. In one implementation of UPCI signaling (which applies to both E-HICH and E-RGCH), the WTRU may receive the UPCI through a variation of this E-HICH/E-RGCH structure.

FIG. **31**A shows an example UPCI signaling using an E-HICH. In this embodiment, a WTRU may be configured to listen to a specific E-HICH channelization code from, for example, an E-DCH serving cell. As shown in FIG. **31**A, the first radio slot **3102** of the E-HICH subframe carries the conventional E-HICH signal while the subsequent two radio slots **3104** of the E-HICH subframe carry the signaling for the UPCI. Alternatively, the first two radio slots of the E-HICH subframe may carry the E-HICH signal while the last radio slot of the E-HICH subframe carry the signaling for the UPCI. Any other variations are also possible. This embodiment allows the network to save on channelization code space, at the expense of additional transmission power to maintain similar reliability level for the E-HICH. The same approach may also be used for the E-RGCH.

The WTRU may be configured to listen to the UPCI periodically, with a certain configured or pre-defined period. In case where the WTRU is not configured to listen to the UPCI, the conventional three radio slots of the E-HICH subframe may carry the conventional E-HICH information (if present). This allows reducing the amount of downlink signaling for support of UL MIMO operations. The same approach may also be used for the E-RGCH. FIG. **31**B illustrates the case where one out of seven E-HICH subframes carries the UPCI field. Even if the Node-B has no ACK/NACK to transmit during those periods, the UPCI field may be transmitted.

In accordance with another embodiment, a new set of orthogonal signature sequences may be used to signal the UPCI via the E-HICH, the E-GRCH, or a different channel. The new signature sequences may or may not be used in combination with the signature hopping pattern of the E-HICH or the E-RGCH. For example, the new sequences may be modulated by +1, −1 by the UPCI information bits.

To carry more than one information bit, multiple sequences may be used. Alternatively, the information bits may modulate a given radio slot in the three slots sequence. For example, the first half of the sub-frame may be modulated by the first information bit of the UPCI, (e.g., a most significant bit (MSB)), while the second half may be modulated by the second information bit of the UPCI, (e.g., a least significant bit (LSB)). Alternatively, in case two UPCI information bits need to be transmitted, two of the three radio slots may be used to transmit the information and the remaining radio slot of the subframe may be DTXed. The radio slots for the UPCI information may not be consecutive, (e.g., the first and third radio slots may be used for the UPCI information and the second radio slot may be DTXed).

The signature sequences may be received by the WTRU at the same time as the conventional sequences over a channelization code that is orthogonal to the one used by the E-HICH/E-RGCH. The WTRU may be configured by the network to monitor one or more such new sequences on one or more E-HICH/E-RGCH. Alternatively, the WTRU may be configured to monitor these sequences for a specific instant of time, (e.g., periodically). This may allow the network to save on transmission power.

In accordance with another embodiment, the WTRU may be configured by the network, in addition to the conventional E-HICH/E-RGCH set, to monitor a dedicated set of E-HICH/E-RGCH conventional sequences that carry the UPCI information.

In accordance with another embodiment, a new feedback channel, (will he referred to as "E-DCH channel stated information channel (E-CSICH)") may be defined to signal the UPCI. In order to have a minimum impact on legacy E-HICH/E-RGCH channels, a new type of dedicated downlink feedback channel E-CSICH may be defined, where a channelization code different from the one used by the E-HICH/E-RGCH is used. The E-CSICH may use an orthogonal signature sequence as in the E-HICH/E-RGCH as a means to allow multiple users sharing the same channelization code and code multiplexing of UPCI bits for a specific WTRU. The signature sequences may comprise a set of orthogonal sequences with a length equal to one slot of the subframe and the sequence may be repeated over multiple slots of the subframe up to the duration of the E-CSICH.

Without loss of generality, in the following E-CSICH examples, two WTRUs in a cell, each having 2-bit UPCI information, are assumed as an example.

FIG. **32** shows an example transmitter **3200** for transmitting UPCI for two WTRUs via an E-CSICH in accordance with one embodiment. The transmitter **3200** includes UPCI mappers **3202**, mixers **3204**, repeaters **3206**, a combiner **3208**, and a channelization unit **3210**. The two bits of UPCI for each WTRU are mapped to a certain value by the UPCI mapper **3202**, respectively. The two UPCI bits may be generated once per TTI, (i.e., one output per 2 ms TTI). An example mapping of the two bit UPCI to a complex value is shown in Table 3. The mapped value of each WTRU is modulated with a different M-bit long orthogonal sequence by the mixer **3204**, and then repeated over N times by the repeater **3206**, where N may be 1 or higher integer. The resulting data for the two WTRUs are combined by the combiner **3208** and spread with a channelization code by the channelization unit **3210**. With this embodiment, different WTRUs may share the same E-CSICH by using different orthogonal sequences.

TABLE 3

UPCI value (decimal/binary)	Output of UPCI mapper
0/00	1 + j
1/01	−1 + j
2/10	1 − j
3/11	−1 − j

FIG. **33** shows another example transmitter **3300** for transmitting UPCI for two WTRUs via an E-CSICH in accordance with another embodiment. In this embodiment, the UPCI information bits of a specific WTRU is time-multiplexed and E-CSICHs for different WTRUs are code-multiplexed. The transmitter **3300** includes mixers **3302**, modulation mappers **3304**, repeaters **3306**, a combiner **3308**, and a channelization unit **3310**. The UPCI information bits, (e.g., one bit per slot), for each WTRU are modulated with a different signature sequence by the mixer **3302**, respectively, which generates M bits per slot where M is the length of the signature sequence. The binary information bits may be mapped to +1 and −1 before applying a signature sequence. In this example, the two UPCI bits are modulated over two slots. The M bits per slot are modulated, (e.g., QPSK), by the modulation mapper **3304** and may be repeated over N times by the repeater **3306**, where N is 1 or higher integer. The resulting two data are combined by the combiner **3308** and spread with a channelization code by the channelization unit **3310**.

FIG. **34** shows another example transmitter **3400** for transmitting UPCI for two WTRUs via an E-CSICH in accordance with another embodiment. In this embodiment, both UPCI information bits of a specific WTRU and E-CSICHs for different WTRUs are code-multiplexed. The transmitter **3400** includes mixers **3402**, modulation mappers **3404**, combiners **3406**, **3410**, repeaters **3408**, and a channelization unit **3412**. Each of the two UPCI bits for each WTRU is modulated with a different M-bit long orthogonal sequence by the mixer **3402**. The binary information bits may be mapped to +1 and −1 before applying a signature sequence. The M bits are modulated by the modulation mapper **3404**, (e.g., QPSK). The modulated UPCI signals for the same WTRU are combined by the combiner **3406**, and then may be repeated over N times by the repeater **3408**, where N may be 1 or higher integer. The resulting data for the two WTRUs are combined by the combiner **3410** and spread with a channelization code by the channelization unit **3412**.

For M=40, the legacy 40-bit long signature sequences may be reused for the orthogonal signature sequences. Alternatively, For M=20, the following twenty 20-bit long sequences may be used as the orthogonal signature sequences.

$$C_{ss,20} = \begin{bmatrix} A & A & B & C \\ -B & -C & A & A \\ -A & A & C & -B \\ -C & B & -A & A \end{bmatrix}$$

where

$$A = \begin{bmatrix} -1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 & 1 \\ 1 & 1 & -1 & 1 & 1 \\ 1 & 1 & 1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 \end{bmatrix};$$

$$B = \begin{bmatrix} 1 & -1 & 1 & 1 & -1 \\ -1 & 1 & -1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & 1 & -1 \\ -1 & 1 & 1 & -1 & 1 \end{bmatrix};$$

$$C = \begin{bmatrix} 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & -1 & -1 \\ -1 & 1 & 1 & 1 & -1 \\ -1 & -1 & 1 & 1 & 1 \\ 1 & -1 & -1 & 1 & 1 \end{bmatrix}.$$

In accordance with another embodiment, the pre-coding weights may be indicated using the E-AGCH. The current 3GPP Release 6 E-AGCH carries up to 6 information bits (5 bits for the absolute grant information and one bit for the absolute grant scope). In accordance with one embodiment, a new E-AGCH structure may be defined to carry the UPCI field in addition to the conventional fields. When a WTRU receives an E-AGCH, the WTRU may use the UPCI weights indicated in the E-AGCH until the next E-AGCH (with potentially different set of UPCI weights to use). This embodiment provides a solution with a small amount of downlink signaling.

In accordance with another embodiment, the absolute grant field of the E-AGCH may be reduced from 5 bits to a smaller value, (e.g., 3 bits), and the free bits may be used for the UPCI field. This allows the network to use similar power level on the E-AGCH and maintain the same level of reliability, at the expense of some granularity on the absolute grant.

In accordance with another embodiment, the pre-coding weights may be indicated using a high speed shared control channel (HS-SCCH). Currently, an HS-SCCH order may be used for activation and deactivation of DTX, discontinues reception (DRX), and HS-SCCH-less operation, for high speed downlink shard channel (HS-DSCH) serving cell change indication, and for the activation and deactivation of secondary serving HS-DSCH cell and secondary uplink frequency. When associated to a high speed physical downlink shared channel (HS-PDSCH), the HS-SCCH carries control information for demodulating the HS-PDSCH.

In accordance with one embodiment, the HS-SCCH order may be used to carry the UPCI by introducing a new HS-SCCH order type. The order bits (3-bits long) of the HS-SCCH may be used to carry the UPCI. For example, any two of the 3 order bits, $x_{ord,1}$, $x_{ord,2}$, $x_{ord,3}$ may indicate 4 possible UPCI values. Alternatively, all 3 order bits may be used to indicate up to 8 possible UPCI values to provide fine granularity of pre-coding weights.

In accordance with another embodiment, as the WTRU needs to monitor up to four HS-SCCHs, the decoded HS-SCCH number may implicitly signal the UPCI. For example, if (the decoded HS-SCCH number) MOD 4=0, 1, 2 and 3 may indicate 4 possible UPCI values, respectively. In the case of multicarrier high speed downlink packet access (MC-HS-DPA) where more than one downlink carrier is activated simultaneously, the HS-SCCH number may refer to the HS-SCCH number carried on the DL carrier associated with the UL carrier which the signaled UPCI will be applied to.

In accordance with another embodiment, the HS-SCCH type 1 and 3 physical channels may be used to signal the UPCI by using and reinterpreting the unused field of the HS-SCCH. For example, 2 more bits may be freed from the channelization code set bits $x_{ccs,1}, x_{ccs,2}, \ldots, x_{ccs,7}$ by only signaling P (15 codes need 4 bits) if O can be signaled via higher layer.

When the WTRU receives an HS-SCCH (either HS-SCCH order or HS-SCCH physical channel), the WTRU may use the UPCI carried in the HS-SCCH until the next HS-SCCH (with potentially different set of UPCI weights to use).

In accordance with another embodiment, the pre-coding weights may be indicated using a fractional dedicated physical channel (F-DPCH). The current 3GPP Release 9 F-DPCH is designed to carry up to 2 bits of TPC command every slot. By assigning a WTRU specific timing offset or slot format, it is possible to multiplex up to 10 WTRUs onto one channelization code for F-DPCH.

In accordance with one embodiment, a second F-DPCH may be transmitted with a different channelization code to signal the UPCI. Given the same time offset of the F-DPCHs, the two F-DPCHs for the same WTRU may be transmitted with the same or different F-DPCH slot format. For the second F-DPCH, the UPCI may be transmitted every slot or every TTI, (e.g., 3 slots). If the UPCI is updated every TTI, the same UPCI may be repeatedly transmitted on 3 consecutive slots, or the updated UPCI may be transmitted on one of the 3 slots and the unused 2 slots may be DTXed or used for signaling the UPCI or TPC commands for other WTRUs.

Alternatively, given the same F-DPCH slot format, two F-DPCHs transmitted to one WTRU may use the same time offset of the F-DPCH for determining the uplink frame time. The two F-DPCHs transmitted to one WTRU may use the different time offset.

Alternatively, a Node-B may transmit one F-DPCH to a WTRU with a different F-DPCH format. FIG. **35** shows an F-DPCH format in accordance with this embodiment. As shown in FIG. **35**, both the TPC field **3502** and the UPCI field **3504** are transmitted in one F-DPCH. By appropriately assigning an F-DPCH slot format, it is possible to time multiplex up to 5 WTRUs configured for uplink MIMO or less than 10 WTRUs configured for MIMO or non-MIMO onto one channelization code for F-DPCH.

The appropriate slot format should be configured for different WTRUs to make sure that there is no overlap between a UPCI field of one WTRU and a TPC field of the other WTRU. For example, 5 odd-numbered slot formats may be configured, (i.e., the F-DPCH slot format number=1, 3, 5, 7, 9) to 5 MIMO WTRUs onto one channelization code for the F-DPCH.

Embodiments for the WTRU to select pre-coding weights are disclosed hereafter.

In accordance with one embodiment, a WTRU may select the pre-coding weights based on the received UPCI. The mapping between the pre-coding weights and the UPCI may be pre-defined in the specification. For example, the pre-coding weights may be mapped to 4 possible UPCI values, (i.e., w_2^{pref}), as shown in Table 4. In Table 4, the first pre-coding weight w_1^{pref} of the preferred primary pre-coding vector (w_1^{pref}, w_2^{pref}) is constant, and therefore, the 2-bit UPCI is sufficient to indicate the pre-coding weight w_2^{pref} For antenna 2. It should be understood that Table 2 is provided as an example, and the mapping between pre-coding weights and the UPCI may be set differently. For the single stream case, some implementation issues such as power imbalance may happen for some of the MIMO codebook. In order to mitigate this power imbalance problem, a restriction may be applied on the uplink codebook choice for the single stream case, (i.e., only a subset of preferred precoding vectors w_2^{pref} may be used.

TABLE 4

w_2^{pref}	UPCI value
$\frac{1+j}{2}$	0
$\frac{1-j}{2}$	1
$\frac{-1+j}{2}$	2
$\frac{-1-j}{2}$	3

The WTRU may select the preferred primary pre-coding vector (w_1^{pref}, w_2^{pref}) based on the UPCI from Node-B, and then select the secondary pre-coding vector which may be a unique function of the primary pre-coding vector. For example, the secondary pre-coding vector may be selected to be orthogonal to the primary pre-coding vector. Specifically, if a single transport block is scheduled in a TTI, the WTRU may use the pre-coding vector (w_1^{pref}, w_2^{pref}) for transmission of that transport block. If two transport blocks are scheduled in a TTI, the WTRU may use two orthogonal pre-coding vectors to transmit the two transport blocks.

In accordance with another embodiment, the WTRU may select the pre-coding weights based on the received full channel matrix or eigen-value components of the channel matrix.

In accordance with another embodiment, the WTRU may select the pre-coding weights based on one or more downlink (DL) control signals and previous pre-coding weights, which may be treated as the implicitly closed-loop transmit diversity scheme.

For a certain time duration, if the WTRU receives the DL control information indicating the reliable transmission, the WTRU may continue to use the same pre-coding weights as the previous one. If the WTRU receives the DL control information indicating unreliable transmission, the WTRU may select the pre-coding weights which form the beam indicating the opposite direction of the previous one. If the WTRU receives the DL control information indicating a mix of reliable and unreliable transmissions, the WTRU may select the pre-coding weights which may or may not be the same pre-coding weights as the previous one.

More specifically, given three inputs: the pre-coding vector used for last transmission (PV(n−1)), trigger, and trigger duration (parameter "period"), the WTRU may select the pre-coding vector for the coming transmission (PV(n)) by the generic feedback control function as follows:

$$PV(n)=f(PV(n-1),\text{trigger}(n-\text{period}+1:n)), \qquad \text{Equation (11)}$$

where n is the time index of TTI or slot depending on the pre-coding vector update rate, and trigger (n-period+1:n) denotes the trigger that the WTRU has received for the time duration by which the WTRU selects the pre-coding vector PV(n). The parameter "period" may be pre-defined or configured by network.

The trigger may be based on any of the following control signals: a received serving grant on DL E-AGCH/E-RGCH from a Node-B, a TPC command pattern on DL DPCCH or F-DPCCH, the sequence of positive acknowledgement (ACK), negative acknowledgement (NACK) or DTX values received, for example, from the E-DCH serving cell, a normalized remaining power margin (NRPM), WTRU power headroom (instantaneous and/or averaged over longer period of time, for example UE power headroom (UPH), and the like.

The function ƒ(PV(n−1), trigger(n−period+1:n)) denotes the generic feedback control scheme, by which the WTRU may select the pre-coding vector PV(n) to be one of the following options based on the pre-coding vector PV(n−1) used for the last transmission and received triggers for last "period" time duration.

Option A: the same pre-coding vector may be used continuously as in the last transmission, (i.e., PV(n)=PV(n−1));

Option B: a new pre-coding vector PV(n) may be selected to be opposite to the last pre-coding vector PV(n−1);

Option C: a new pre-coding vector PV(n) may be selected by any of the following: (1) a default value configured by network, (e.g., via radio resource control (RRC) signaling), (2) a default value set in the specifications, a next pre-coding index (modulo the number of elements in the codebook), (3) a previous pre-coding vector index, (4) a random selection by any of the following: uniformly distributed among all pre-coding vectors, uniformly distributed among all other pre-coding vectors, uniformly distributed among all other precoding vectors excluding the orthogonal vector, and no particular distribution specified, (5) the mostly used pre-coding vector in the past N time intervals, where N may be any pre-defined or configured value, (6) the vector orthogonal to the mostly used pre-coding vector in the past N time intervals, (7) other vectors in UL MIMO pre-coding codebook except the pre-coding vector selected by Option A or Option B, etc.

For initialization of the function ƒ(PV(n−1), trigger(n−period+1:n)), PV(0) may be pre-defined value in the specifications, or configured by network via RRC signaling, or any pre-code vector randomly selected in the UL MIMO codebook. For time duration n=1, PV(n)=PV(0).

Example implementations of the above embodiment for selecting the pre-coding vector using the function ƒ(PV(n−1), trigger(n−period+1:n)) are given below.

In the first example implementation, the WTRU may select the pre-coding weights based on trigger 1, (i.e., based on the received serving grant (SG) on the E-AGCH and the E-RGCH from the Node-B), by using the following feedback control scheme. If the WTRU receives continuously increased SG for a period, the WTRU may select the PV(n) by Option A. If the WTRU receives continuously decreased SG for a period, the WTRU may select the PV(n) by Option B. If the WTRU receives alternatively increased and decreased SG for a period, the WTRU may select the PV(n) by Option C.

In the second example implementation, the WTRU may select the pre-coding weights based on trigger 2, (i.e., a TPC command pattern on DL DPCCH/F-DPCCH from the Node-B), by using the following feedback control scheme. If the WTRU receives continuously decreased TPC command, (i.e., TPC_cmd=−1), for a period, the WTRU may select the PV(n) by Option A. If the WTRU receives continuously increased TPC commands, (i.e., TPC_cmd=1), for a period, the WTRU may select the PV(n) by Option B. If the WTRU receives alternatively increased and decreased TPC commands, (e.g., TPC_cmd=1,−,1,−1 . . .), for a period, the WTRU may select the PV(n) by Option C.

In the third example implementation, the WTRU may select the pre-coding weights based on trigger 3, (i.e., the sequence of ACK/NACK/DTX values received, for example, from the E-DCH serving cell), by using the following feedback control scheme. If the WTRU receives continuously ACK for a period, the WTRU may select the PV(n) by Option A. If the WTRU receives continuously NACK for a period, the WTRU may select the PV(n) by Option B. If the WTRU receives ACK and NACK, or ACK, NACK, and DTX, alternately, (or DTX), for a period, the WTRU may select the PV(n) by Option C.

In the fourth example implementation, the WTRU may select the pre-coding weights based on trigger 4, (i.e., a NRPM), by using the following feedback control scheme. If the WTRU determines continuously increased NRPM for a period, the WTRU may select the PV(n) by Option A. If the WTRU determines continuously decreased NRPM for a period, the WTRU may select the PV(n) by Option B. If the WTRU determines alternatively increased and decreased NRPM for a period, the WTRU may select the PV(n) by Option C.

The pre-coding weights for the primary stream in a dual-stream transmission may not be selected to be the same as the weights for the single-stream transmission. This is due to the fact that the weight generation for diversity may be different from the one for spatial-multiplexing. Thus, the WTRU may have to select from two sets of weights depending on the number of streams being transmitted. For example, the Node-B may indicate to the WTRU two sets of preferred weights: one set of preferred weights in case of single-stream transmission and another set of weights for dual-stream transmission. The WTRU, for example, may apply the appropriate weights on a TTI by TTI basis depending on the number of stream. This method may be applied to any weight selection described above and below.

When WTRU is in soft handover, the pre-coder weights may be selected based on the following two embodiments.

In accordance with a first embodiment, a radio network controller (RNC) may emphasize the E-DCH serving cell to determine the preferred pre-coding weights. In this case, all cells in the active set reports their estimated channel matrix (or channel state information (CSI)), to the RNC, and then the antenna weight vector (W) may be determined by the RNC so as to maximize the criteria function P:

$$P=W^H(\alpha(H_1^H H_1)+(1-\alpha)(H_2^H H_2+\dots))W, \quad \text{Equation (12)}$$

where H_k is the estimated channel matrix at cell k, cell #1 is the E-DCH serving cell, and coefficient α is the pre-defined parameter that is less than or equal to 1. For example, α=0.7 to emphasize the serving cell performance. The UPCI may be feedback to the WTRU to select the pre-coding weights.

In accordance with a second embodiment, the WTRU may use a majority rule to select the pre-coding weights based on multiple received UPCIs from different cells in the active set.

In accordance with a third embodiment, the WTRU may use the pre-coding weights signaled by the serving E-DCH cell, or derived from the serving E-DCH cell signals.

Embodiments for a WTRU to signal the pre-coding weights are disclosed hereafter. After the selected pre-coding weights are applied by the WTRU, the UL pre-coding vector may or may not be signaled to the UTRAN. If the WTRU is not allowed to override the signaled pre-coding weights by the Node-B, it is not necessary for the WTRU to signal it. If the WTRU is allowed to override the signaled pre-coding weights by the Node-B or the WTRU may determine the preferred pre-coding weights, the WTRU needs to signal it to the UTRAN.

The pre-coding weight information may be indicated by using a different second pilot sequence pattern that is sent on an UL DPCCH2. For example, in case where the DL MIMO pre-coding matrix is reused for the UL MIMO, whose weights w_1, w_2, w_3 and w_4 of the 2×2 pre-coding matrix are given by Equations (12)-(14), 4 different pilot patterns are needed to map to 4 possible selection of w_2. Alternatively, the pre-coding weight information may be carried on a non-pilot field of the second UL DPCCH, (i.e., DPCCH2). Alternatively, the pre-coding weight information may be carried on the second UL E-DPCCH, (i.e., E-DPCCH2), by replacing the happy bit. Since the happy bit field may carry 1 bit of information, this approach may in practice be applicable to antenna switching, as an example. Additional signaling or codeword restriction may be necessary if additional information needs to be transmitted.

Embodiments for a Node-B to transmit channel state information are explained hereafter.

Instead of the codebook index, a Node-B may feed back to the WTRU quantized phase and amplitude/power offsets between two transmit antennas of the WTRU. In addition, for spatial multiplexing, the rank information needs to be fed back to the WTRU. The embodiments for sending the UPCI disclosed above and/or their combinations may be reused or extended to signal the channel station information and/or the rank information. For example, the E-CSICH may be used to send the index of quantized phase offset indication (PHI), the index of power offset indication (POI), and rank indication (RI).

Example transmitter structures of using E-CSICH to signal the channel state information UPCI, PHI, POI, and RI for two MIMO WTRUs are disclosed below. Without loss of generality, 2-bit UPCI, 2-bit PHI, 2-bit POI and 1-bit RI are assumed.

FIGS. **36** and **37** show signaling of PHI and POI using the transmitter structure shown in FIGS. **32** and **34**, respectively.

In FIG. **36**, the transmitter **3600** includes PHI mappers **3602**, POI mappers **3603**, mixers **3604**, a combiner **3606**, **3610**, repeaters **3608**, and a channelization unit **3610**. The PHI bits and POI bits for each WTRU are mapped to a certain value by the PHI mapper **3602** and POI mapper **3603**, respectively. The PHI and POI mappers **3602**, **3603** may use the UPCI value mapping given in Table 3. The mapped value of each WTRU is modulated with a different M-bit long orthogonal sequence by the mixer **3604**, and then combined by the combiner **3606**, and then repeated over N times by the repeater **3608**, where N may be 1 or higher integer. The resulting data for the two WTRUs are combined by the combiner **3610** and spread with a channelization code by the channelization unit **3612**.

The transmitter **3700** in FIG. **37** includes mixers **3702**, **3703**, modulation mappers **3704**, combiners **3706**, **3710**, repeaters **3708**, and a channelization unit **3712**. The PHI and POI bits for each WTRU are modulated with a different M-bit long orthogonal sequence by the mixer **3702**, **3703**, respectively. The binary information bits may be mapped to +1 and −1 before applying a signature sequence. The M bits are modulated by the modulation mapper **3704**, (e.g., QPSK). The modulated UPCI signals for the same WTRU are combined by the combiner **3706**, and then may be repeated over N times by the repeater **3708**, where N may be 1 or higher integer. The resulting data for the two WTRUs are combined by the combiner **3710** and spread with a channelization code by the channelization unit **3712**.

FIGS. **38** and **39** show signaling of UPCI and RI using the transmitter structure shown in FIGS. **32** and **34**, respectively. The transmitter structure of FIGS. **38** and **39** are substantially similar to the transmitter structure in FIGS. **36** and **37**, respectively. Therefore, the details of the transmitter structure in FIGS. **38** and **39** will not be explained for simplicity. Example RI mapping is given in Table 5.

TABLE 5

Rank	RI value (decimal/binary)	Output of RI mapper
1	1/0	1 + j
2	2/1	−1 + j

FIG. **40** shows an example frame format for the E-CSICH. For 2 ms TTI, the duration of the E-CSICH may be 2 ms, and for 10 ms TTI, the duration of E-CSICH may be 10 ms.

The sequence $b_{i,0}, b_{i,1}, \dots, b_{i,M-1}$ transmitted in slot i in FIG. **40** is given by $b_{i,j}=aC_{ss,M,m(i)j}$, where 'a' is the output of the RI/UPCI/POI/PCI mapper for the transmitter structure in FIG. **32**, and a=+1/−1 for the transmitter structure in FIGS. **33** and **34**. The index m(i) in slot i may take value from 0 to M−1.

The E-AGCH may be used to carry the channel state information. For example, for MIMO-capable WTRUs, the E-AGCH may use a spreading factor of 128 so that CSI may be multiplexed with absolute grant value and absolute grant scope.

Upon reception of the CSI at the receiver, the WTRU applies the received values for transmission. The RI indicates how many streams the WTRU may transmit in the next time interval, (e.g., until reception of a new RI). If the RI indicates dual-stream transmission, the WTRU may transmit up to two transport blocks simultaneously. The RI may be indicated to the MAC layer for E-TFC selection which provides up to two transport blocks according to the available grant, power and data. Alternatively, when the RI indicates dual-stream transmission, the WTRU may multiplex coded bits of a single transport block onto two physical streams.

The PHI and POI indicate the phase offset index and the power offset index of the second antenna with respect to the first antenna. The WTRU then determines the phase offset value (ϕ) and the power offset value (γ).

The WTRU may apply a unity weight to the first antenna ($w_1=1$) and calculates the weight for the second antenna (w_2) using one of the following equations, depending on the actual meaning of the power offset.

$$w_2=\sqrt{\gamma}e^{i\phi} \text{ or} \quad \text{Equation (13)}$$

$$w_2=e^{\sqrt{\gamma}+i\phi}. \quad \text{Equation (14)}$$

Alternatively, the WTRU may calculate the weight for the first and second antennas to have a unit transmission gain across the two antennas. This may be achieved, for instance by normalizing w_1 and w_2 as calculated above using equations (19) and (20) (using, without loss of generality, the first expression for w_2 above):

$$w_1=\frac{1}{\sqrt{1+\gamma}}, \text{ and} \quad \text{Equation (15)}$$

$$w_2=\frac{\sqrt{\gamma}}{\sqrt{1+\gamma}}e^{i\varphi}. \quad \text{Equation (16)}$$

The secondary pre-coding vector may then be calculated as the orthogonal vector to the calculated primary pre-coding weight as follows.

$$w_3=\frac{-\sqrt{\gamma}}{\sqrt{1+\gamma}}, \text{ and} \quad \text{Equation (17)}$$

$$w_2=\frac{1}{\sqrt{1+\gamma}}e^{i\varphi}. \quad \text{Equation (18)}$$

The whole unitary precoding matrix may be expressed as:

$$W=\begin{bmatrix} w_1 & w_3 \\ w_2 & w_4 \end{bmatrix}. \quad \text{Equation (19)}$$

This approach allows maintaining a unitary precoding matrix while having a non-zero power offset between the two antenna elements thus potentially providing better performance.

Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

What is claimed is:

1. A method implemented in a wireless transmit/receive unit (WTRU) for uplink transmission using multiple antennas, the method comprising:

processing at least one enhanced dedicated channel (E-DCH) dedicated physical data channel (E-DPDCH), a first dedicated physical control channel (DPCCH), and a second DPCCH to generate a first data stream and a second data stream, wherein the first data stream includes the first DPCCH and the second data stream includes the second DPCCH;

applying pre-coding weights to the generated first data stream and the second data stream; and

transmitting the first data stream and the second data stream via a plurality of antennas, wherein the first stream and the second stream carry a same pilot sequence and the first stream and the second stream are transmitted using different channelization codes.

2. The method of claim **1** wherein the first data stream includes at least one of an E-DCH dedicated physical control channel (E-DPCCH), a high speed dedicated physical control channel (HS-DPCCH), or a dedicated physical data channel (DPDCH).

3. The method of claim **1** wherein a pre-coding weight matrix of the pre-coding weights is diagonal.

4. A wireless transmit/receive unit (WTRU) for uplink transmission using multiple antennas, the WTRU comprising:

a physical layer processing block configured to process at least one enhanced dedicated channel (E-DCH) dedicated physical data channel (E-DPDCH), a first dedicated physical control channel (DPCCH), and a second DPCCH to generate a first data stream and a second data stream, wherein the first data stream includes the first DPCCH and the second data stream includes the second DPCCH;

a pre-coding block configured to apply pre-coding weights to the generated first data stream and the second data stream; and

a plurality of antennas for transmitting the first data stream and the second data stream, wherein the first stream and the second stream carry a same pilot sequence and the first stream and the second stream are transmitted using different channelization codes.

5. The WTRU of claim **4** wherein the first data stream includes at least one of an E-DCH dedicated physical control channel (E-DPCCH), a high speed dedicated physical control channel (HS-DPCCH), or a dedicated physical data channel (DPDCH).

6. The WTRU of claim **4** wherein a pre-coding weight matrix of the pre-coding weights is diagonal.

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